POWER

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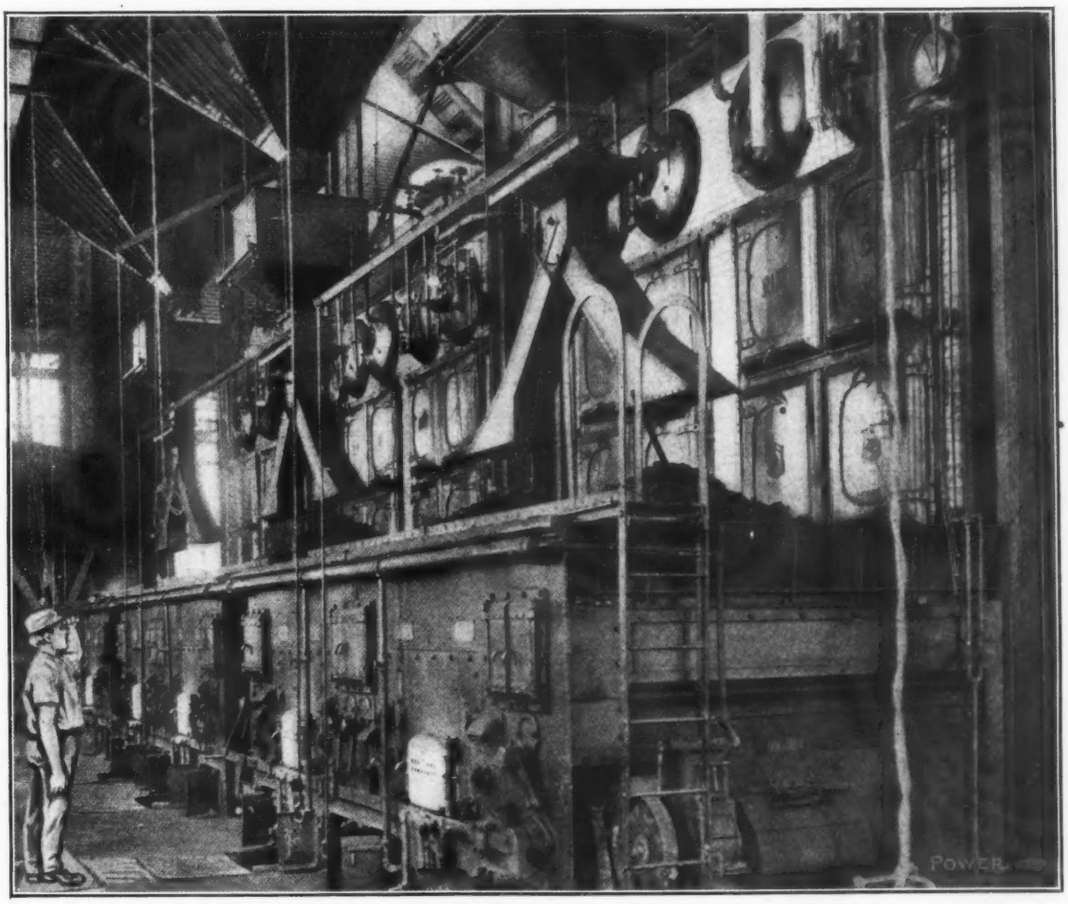
The Water Level



Did you ever experience that hair-raising, knee-weakening, heart-stopping sensation that comes when the water level in the boiler has gone out of sight in the gage-glass—gone so far below the bottom gland-nut that you didn't know where it was?

Maybe you opened the water column drain and water came. Looked good, didn't it? And you made up your mind to be more careful.

Probably there was a reason why the water got so low before you discovered it. Gage-glasses will get coated with lime, etc., and if badly so, when as far away as in the picture, it becomes difficult to ascertain the water level.

It is easy to "lose" the water when carrying heavy loads. The gage-glass is the only tell-tale. Keep it clean and renewed when dirty. It pays.

Nashawena Steam Turbine Plant

By Warren O. Rogers

One of the most uptodate power plants in New Bedford. The mill has 126,000 spindles and a slight variation below normal in the speed of the generating units is greatly multiplied at the spindles. Motor drive is utilized and the loss of output has been reduced to a minimum, due to the constant electrical energy maintained by the turbine units.

One of the latest cotton mills to be added to the large number in the city of New Bedford, Mass., is the Nashawena, which at present has 126,000 spindles and a floor space for a total of 165,000.

The plant necessary to provide power and heat for this mill consists of sixteen 300-hp. vertical boilers set in two rows of eight each, Fig. 1. These boilers are in batteries of two and set in two rows forming a wide alley between them, thus providing space for steam and water mains, also the main smoke flue, which runs above the boilers, Fig. 4, to the outer end of the boiler room to a 260-ft. concrete chimney.

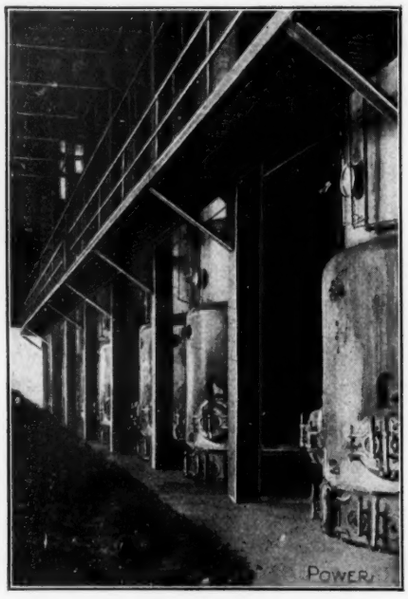


FIG. 1. ROW OF EIGHT BIGELOW-MANNING BOILERS

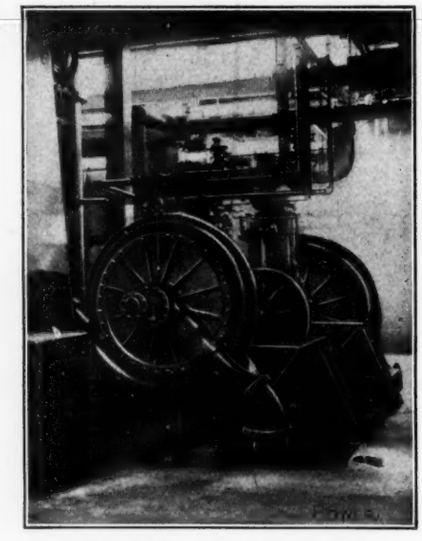


FIG. 2. CIRCULATING PUMPS

PIPING

Two 14-in. steam mains running to a header through this alley, are suspended at a height to bring the 19-in. steam header, which runs at right angles with the two 14-in. mains, low enough for the branch pipes leading to the turbine to come just below the turbine-room floor; the branch pipes are then brought up and connected with the turbines.

A 7-in. steam pipe from each boiler drops from a side connection in the steam main. An angle, nonreturn valve serves to cut each boiler out of the line when necessary.

Brass main and branch feed pipes are used. The main 6-in. feed pipe is suspended midway between the boiler rows, and 2-in. branches connect with the boilers. This arrangement of piping has the advantage that the same structural work is used to support both the steam mains and the feed line. The 2½-in. boiler blowoff pipes connect with a 4-in. main blowoff line placed in a trench, between the boilers. It extends through the boiler room to the water front. Fig. 3 shows a general plan of the plant piping.

A grated platform runs in front of the boilers on the firing side, and a wide grating has been built on the opposite side between the two rows of boilers. It is supported by the same metal work from which the piping is suspended. The main steam pipes are fitted with stop valves, operated from the floor by chains and sprocket wheels.

At one side, occupying a corner formed by the walls of the turbine and boiler

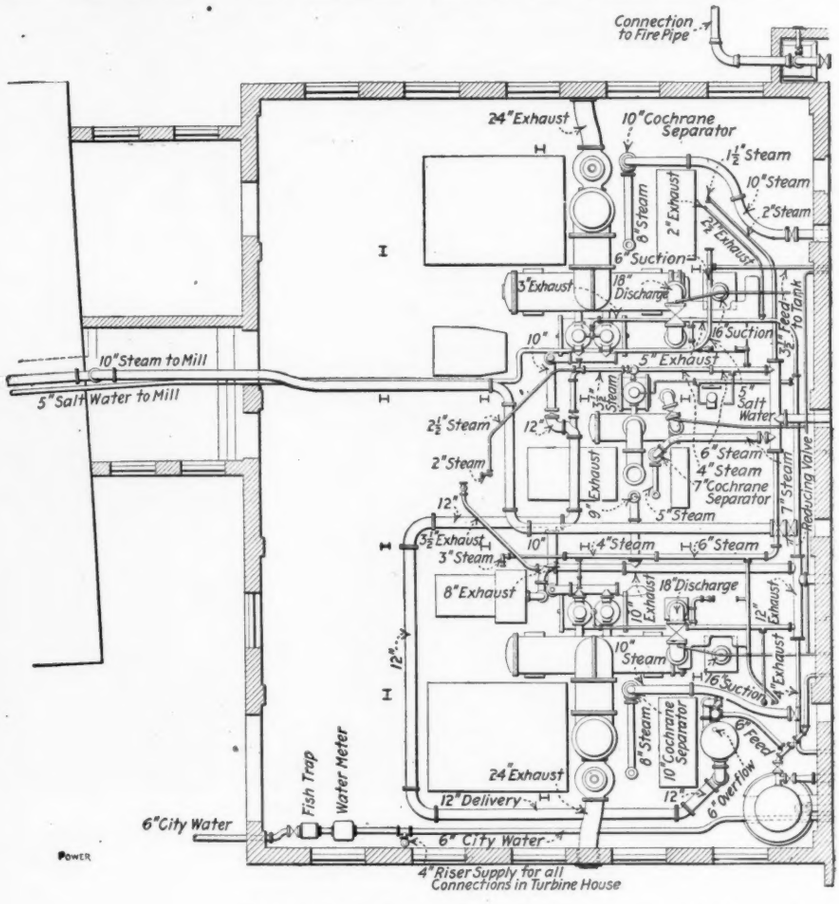


FIG. 3. PLAN OF THE POWER PLANT OF THE NASHAWENA

rooms, is the pump room in which are two 14 and 10 by 18-in. outside-packed, boiler-feed pumps, and one injector. These boiler feeders are so piped that water can be taken from the hot-water tank under a water-weighing machine through which all the return and make-up water flows, or it can be taken direct from the city 6-in. main. The returns from the condensers come into a hot-water tank through a 12-in. pipe, and are pumped into a 3000-hp. open feed-water heater in the boiler room. The hot water goes from the heater to the water weigher, feed pumps and boilers in succession. The returns from all traps and auxiliaries are piped to the hot well from which they are pumped to the heater from which it flows to the water weigher by gravity.

Electrical Units

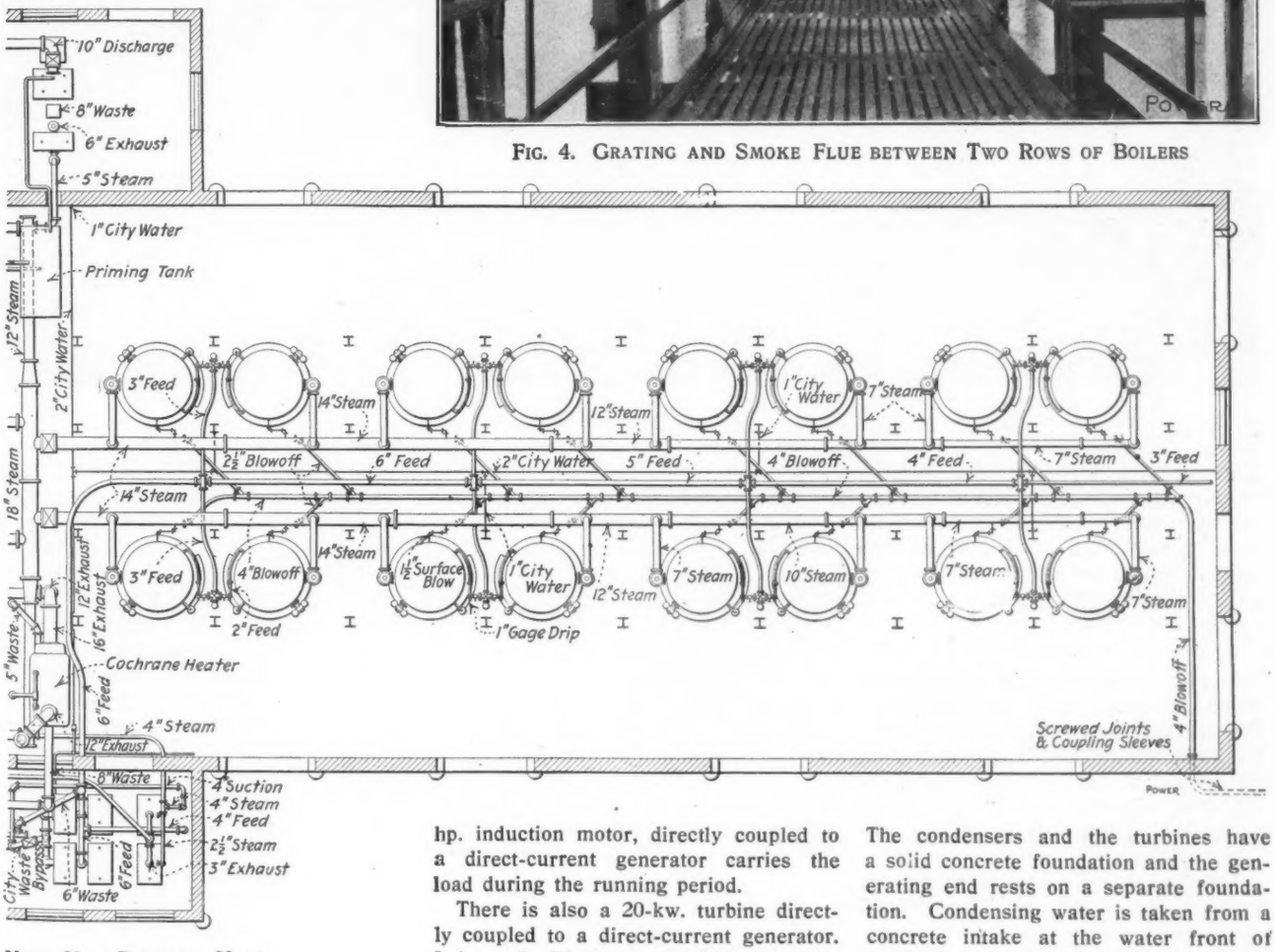
Three turbines generate the electrical energy. Two of them are of 3000 kw. capacity, at a speed of 1800 r.p.m., and one is a 500-kw. unit, at 3600 r.p.m. All generators deliver three-phase, 60-cycle current at 600 volts. These units receive exciting current from a noncondensing 100-kw. turbine, directly coupled to a direct-current generator, which runs at 2400 r.p.m. and is used for starting up in the morning. When the main turbines are up to speed, a 150-hp. induction motor, directly coupled to a direct-current generator carries the load during the running period.

There is also a 20-kw. turbine directly coupled to a direct-current generator. It is used with the small 500-kw. turbine unit. Fig. 5 shows two views of the turbine room.

Condensers

The surface condensers are in the basement between the turbine foundations. The two larger ones have a heating surface of 7000 sq.ft.; the small one, 1650 sq.ft. The condenser circulating pumps and air pumps, Fig. 2, can be seen from the turbine floor through an opening.

Fig. 4. Grating and Smoke Flue between Two Rows of Boilers



Mill, New Bedford, Mass.

The condensers and the turbines have a solid concrete foundation and the generating end rests on a separate foundation. Condensing water is taken from a concrete intake at the water front of the harbor, by the circulating pumps in the basement, through a 16-in. suction pipe.

A 15-ton, hand-operated crane travels the length of the turbine room. A removable floor at one corner of the room, permits of hoisting parts of machines from the basement, which is on the ground level.

EQUIPMENT OF THE NASHAWENA MILL POWER PLANT

No.	Equipment	Kind	Purpose	Kw.	Volts	Amp	Phase	Cycles	R.p.m.	Size	Pressure Lb.	Hp.	Manufacturers
16	Boilers	Vertical	Steam gen.	..	...	...	..	..	..	.....	150	300	Bigelow Co.
2	Pumps	Warren	Boiler feed	..	...	...	..	..	..	14x10x18"	150	...	Warren Steam Pump Co.
1	Weigher	Willcox	Water	..	...	...	..	..	..	.....	...	...	Willcox Engineering Co.
1	Heater	Cochrane	Feed water	..	...	...	..	..	..	.....	...	...	Harrison Safety Boiler Works
1	Turbine	Horizontal	Gen. unit	500	...	...	..	..	3600	.....	150	...	Allis-Chalmers Co.
2	Turbines	Horizontal	Gen. units	3000	...	...	..	..	1800	.....	150	...	Allis-Chalmers Co.
1	Generator	A. C.	Gen. unit	500	600	...	3	60	3600	.....	...	...	Allis-Chalmers Co.
2	Generators	A. C.	Gen. units	3000	600	...	3	60	1800	.....	...	...	Allis-Chalmers Co.
1	Turbine	Curtis	Exciter	100	...	...	..	..	2400	.....	150	...	General Electric Co.
1	Generator	D. C.	Exciter	100	125	800	..	..	2400	.....	...	....	General Electric Co.
1	Motor	Induction	Exciter	..	...	...	3	60	..	.....	...	150	General Electric Co.
1	Generator	D. C.	Exciter	100	125	800	..	..	..	.....	...	...	General Electric Co.
1	Turbine	Curtis	Exciter	520	...	...	..	..	..	.....	150	...	General Electric Co.
1	Generator	D. C.	Exciter	..	125	...	..	..	..	.....	...	...	General Electric Co.
1	Condenser	Surface	Turbine	..	...	...	..	..	..	1650 sq.ft.	...	...	Wheeler Condenser & Engineering Co.
2	Condensers	Surface	Turbines	..	...	...	..	..	..	7000 sq.ft.	...	...	Wheeler Condenser & Engineering Co.
3	Pumps	Edwards	Air	..	...	...	..	..	..	.....	...	...	Wheeler Condenser & Engineering Co.

The floor of the turbine room is of hard maple, and strips of rubber matting are placed where walking is necessary. The walls are white vitrified brick with nile-green trimmings.

FIG. 5. TWO VIEWS OF THE TURBINE ROOM

The switchboard runs lengthwise of the turbine room; the cables drop down to the basement and lead to the factory building through a tunnel, which also contains the steam and water pipes.

Corrosion

In commenting upon the memorandum annually addressed to the Manchester Steam Users' Association by its engineer, C. E. Stromeyer, which this year deals largely with the subject of corrosion, *The Engineer*, of London, broadens out into the following consideration of the general subject.

But the more we study corrosion the more we are forced to the conclusion that it is a very complex and very variable phenomenon. It can only in rare instances be dealt with in the laboratory and then generally only in cases where the chemical reactions are so pronounced as to leave no doubt about their nature. It must be remembered that the user of a vessel of iron or steel for industrial purposes calls all the eating away of such vessel corrosion. He does not distinguish between the direct dissolution of the metal, say by a strong acid, and the slow oxidizing effect produced by water and air. In the first case the chemist has not much difficulty in putting his finger on the trouble, while in the latter, as, for example, in the unequal corrosion of ships' bottoms or propellers or condensers, he is faced by problems so complex that no results worthy of consideration are to be expected from the test-tube experiments. In such cases the only hope is to work on a large scale and under conditions as nearly as possible the duplicate of those actually existing. For example, the condenser with which trials are now being made by a committee of the Institute of Metals will certainly teach us more about the corrosion of condenser tubes than the whole series of tests made by hanging up little bits of alloys in beakers on a laboratory shelf.

The chemist takes a piece of pure iron first for his experiments. It is washed free from every trace of grease, ignited to drive off occluded gases, and handled with consummate skill and care, is introduced into some pure reagent, the action of which it is desired to investigate. The steel of bridges and boilers is stained by a thousand hands, is battered by hammering and bending till it is full of strains and stresses, and above all it is a most complex structure of iron and other things added voluntarily or involuntarily.

We doubt if anyone who has not made the attempt for himself can conceive the irregularity of even the purest iron. By using a delicate galvanometer it has been found that two identical fragments of almost pure Swedish iron would give a marked deflection in ordinary tap water. A touch on the surface of one piece is sufficient to deposit grease from the hands which reverses or still further upsets the balance. The presence of a little oxide on one while the other is clean is strongly indicated. With ordinary commercial iron and steel the results are far more marked and far more uncertain. Let anyone cut a small piece of steel from a boiler plate, divide it in two, plunge the parts in ordinary water at ordinary temperatures and couple them up to a fairly delicate galvonometer. They will undoubtedly give a deflection.

Whether a galvanic action is inseparable from corrosion or not is a debatable point which may here be neglected for we know, at least with certainty, that where there is galvanic action there is wasting away, and that is all we require to know. In a boiler a score of things are present that upset the balance and initiate corrosion. To begin with, the plates have natural variation in composition, then here and there mill scale—

a very powerful positive element more active than copper in a copper-zinc couple—adheres to the plates; again, every rivet hole is surrounded by a border of highly stressed material which probably gives a marked electrical reaction with neighboring less stressed portions. The flanged ends, particularly if they are flogged into place—as too many are—with sledge hammers and dollies, are full of stresses at the corners, stresses which there is little doubt upset the electrical stability. Finally, when under steam, there is the breathing and working of the plates, all offering conditions which invite the production of corrosion. It is with a complexus like this that the investigator of boiler corrosion has to deal, and we say without fear of contradiction that no laboratory experiment can be conceived that will give any information that is not better won from tests and examination and careful thinking about boilers themselves. When, moreover, the tests are carried out on little specimens hung in beakers, they are more than ever valueless for practical application. Plates of at least a foot square should be used so that the uncertainty caused by the difficulties of removing oxides before weighing may be at least reduced.

Melting Points of Firebrick

In bulletin No. 10, C. W. Kanolt, assistant physicist of the Bureau of Standards, describes a series of tests recently conducted to determine the melting points of different kinds of firebrick. Fifty-four samples were used, including fireclay, bauxite, silica, magnesia and chromite brick. The melting points were determined in an electric vacuum furnace and the temperatures were measured with an optical pyrometer. The results are given in Table 1. All the bricks tested were made in the United States. Each melting point given is the mean of at least two determinations. The mean of the melting points of the 41 samples of fireclay bricks is 1649 deg.

TABLE 1. MELTING POINTS OF FIREBRICKS

Sample	Melting Point	Sample	Melting point
Fireclay brick	Deg.	Fireclay brick-con.	Deg.
1	1630	37	1650
2	1635	38	1660
3	1605	47	1725
4	1605	48	1705
5	1705	49	1715
6	1705	*53	1635
7	1700	*54	1635
8	1700	*55	1685
9	1675	*56	1605
10	1710		
11	1660	Bauxite brick:	
12	1555	19	1760
13	1635	20	1740
14	1630	44	1720
15	1655	45	1785
17	1650	46	1720
21	1615	50	1665
22	1640	51	1565
23	1660	52	1590
24	1660		
25	1715		
26	1695	Silica brick:	
27	1600	39	1700
28	1695	40	1705
29	1595	41	1700
30	1560		
31	1600	Chromite brick:	
32	1650	42	2050
33	1655		
34	1570	Magnesia brick:	
35	1650	43	2165
36	1590		

*Samples 53, 54, 55 and 56 are of the same brands as 4, 9, 7 and 17, respectively, but from different lots.

TABLE 2. MELTING POINTS OF MATERIALS ENTERING INTO FIREBRICK

	Deg.		Deg.
Kaolin	1740	Bauxite	1820
Pure alumina	2010	Bauxite clay	1795
Pure silica	*1750	Chromite	2180

*This is not the true melting point but represents approximately the temperature at which silica flows distinctly.

The melting points of materials important in the manufacture of firebrick were also determined and are given in Table 2.

A heavy cylinder oil should not be fed at the same rate, in drops per minute, as a lighter oil, for there is more substance in a drop of heavy than in a drop of light oil.

The Flow of Steam Through Pipes

By H. V. Carpenter*

By the use of the accompanying charts the amount of steam which will flow per minute through a pipe of given diameter with a given loss of pressure; or the loss of pressure occasioned by allowing steam of a given pressure to pass through a pipe of given size with a given velocity and kindred problems may be solved without calculation. A little study of the charts in connection with the examples given in the article will make their use easy.

*Professor of mechanical and electrical engineering, State College of Washington.

There is perhaps no phase of power-plant design in which the rule-of-thumb methods are still adhered to so commonly as in the determination of the proper size of steam pipes.

This is due, apparently, to several reasons; the commonly accepted formulas are complex, are not any too well substantiated by experimental data, nor based on sound theory; the tables given by various writers are incomplete and inconvenient. The engineer who installs pipes which are too large will seldom be criticized, for the mistake shows but slightly in the first cost of the entire plant and the large radiation losses remain unnoticed. Undoubtedly, also, many designers overestimate the importance of keeping the pressure drop in the lines low. Loss of pressure in a pipe line carrying any fluid is due to friction, of course, and results in the transformation of energy of motion of the fluid as a whole into molecular energy or heat. In a water line this heat is usually a total loss, but with steam flowing in well covered pipes most of this heat is carried on with the steam, raising its temperature or its quality above that which would otherwise result. Thus instead of being able to figure the per cent. loss of power as being equal to the per cent. loss of pressure, as is usually true for water or electricity, we find the loss is materially reduced by the return of the heat to the steam. Or, stated more definitely, the total energy of each pound of steam just after entering the pipe is,

heat energy + pressure × volume energy + energy of velocity along the pipe

Just before leaving the pipe we find that the heat energy has been drawn upon to increase the volume and also to increase the velocity of the steam, while at the same time the friction has been absorbing a part of the energy of velocity and returning it in the form of heat energy. So, if the pipe could be perfectly insulated all the energy entering the pipe would be delivered at the other end but in a slightly less available condition.

In view of the complexity of these reiations when radiation losses must be considered, and the extreme difficulty of getting accurate and complete experimental data, it is not surprising that we have no very well established formulas. The following, stated first by Unwin and accepted after extensive tests by R. C. Carpenter and G. H. Babcock, is probably correct enough for ordinary conditions:

$$V = 16{,}050\sqrt{\frac{Pd}{Ly\left(1+\frac{3.6}{d}\right)}}$$

or

$$W = 87.5\sqrt{\frac{Pyd^5}{L\left(1+\frac{3.6}{d}\right)}}$$

Where

V = Velocity of the steam in ft. per min.;
P = Drop in pressure in the length L;
d = Diameter of pipe, in.;
y = Density of the steam, lb. per cu.ft.;
W = Weight of steam delivered, lb. per min.

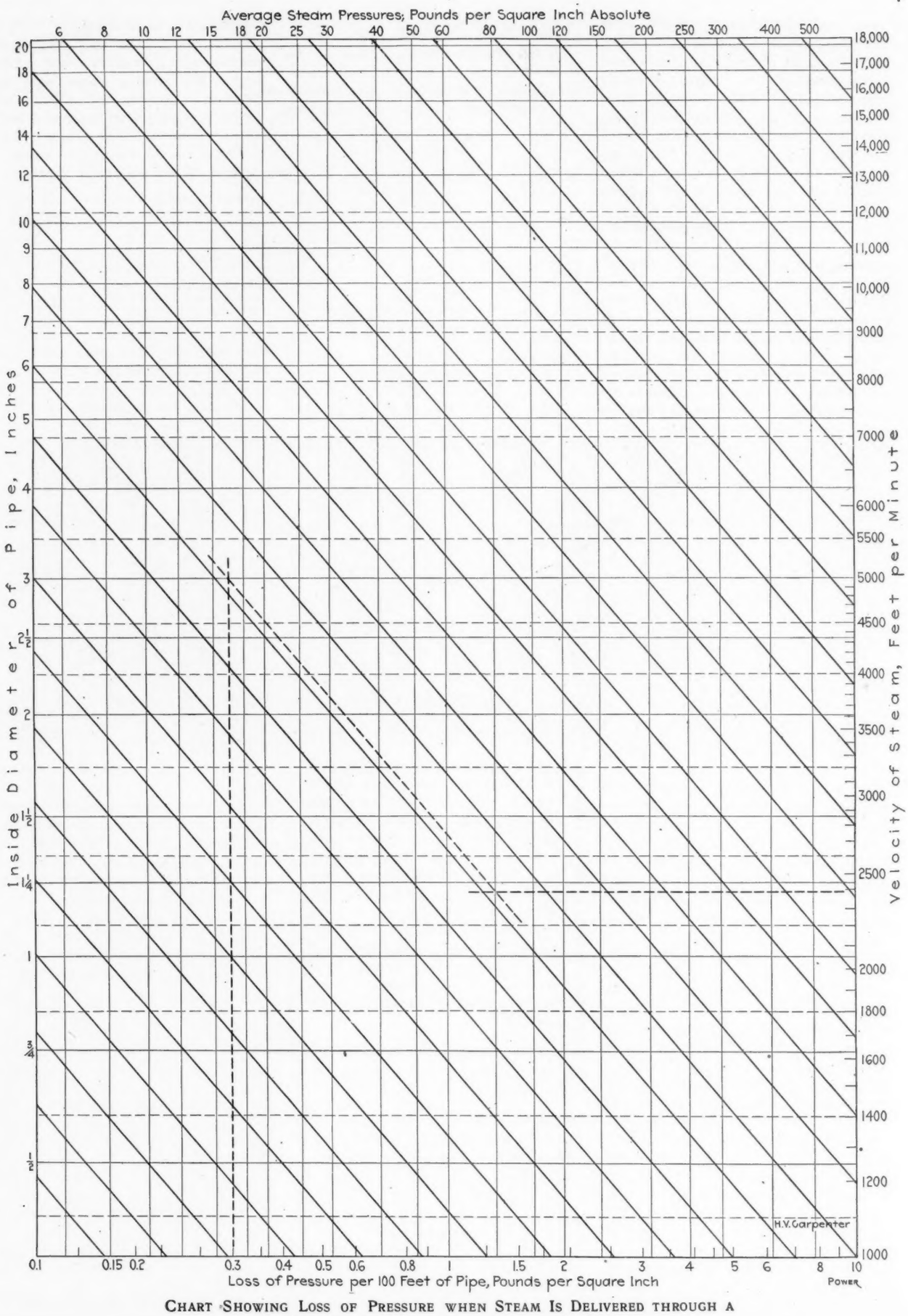


CHART SHOWING LOSS OF PRESSURE WHEN STEAM IS DELIVERED THROUGH A GOOD PIPE OF GIVEN SIZE AT A GIVEN VELOCITY

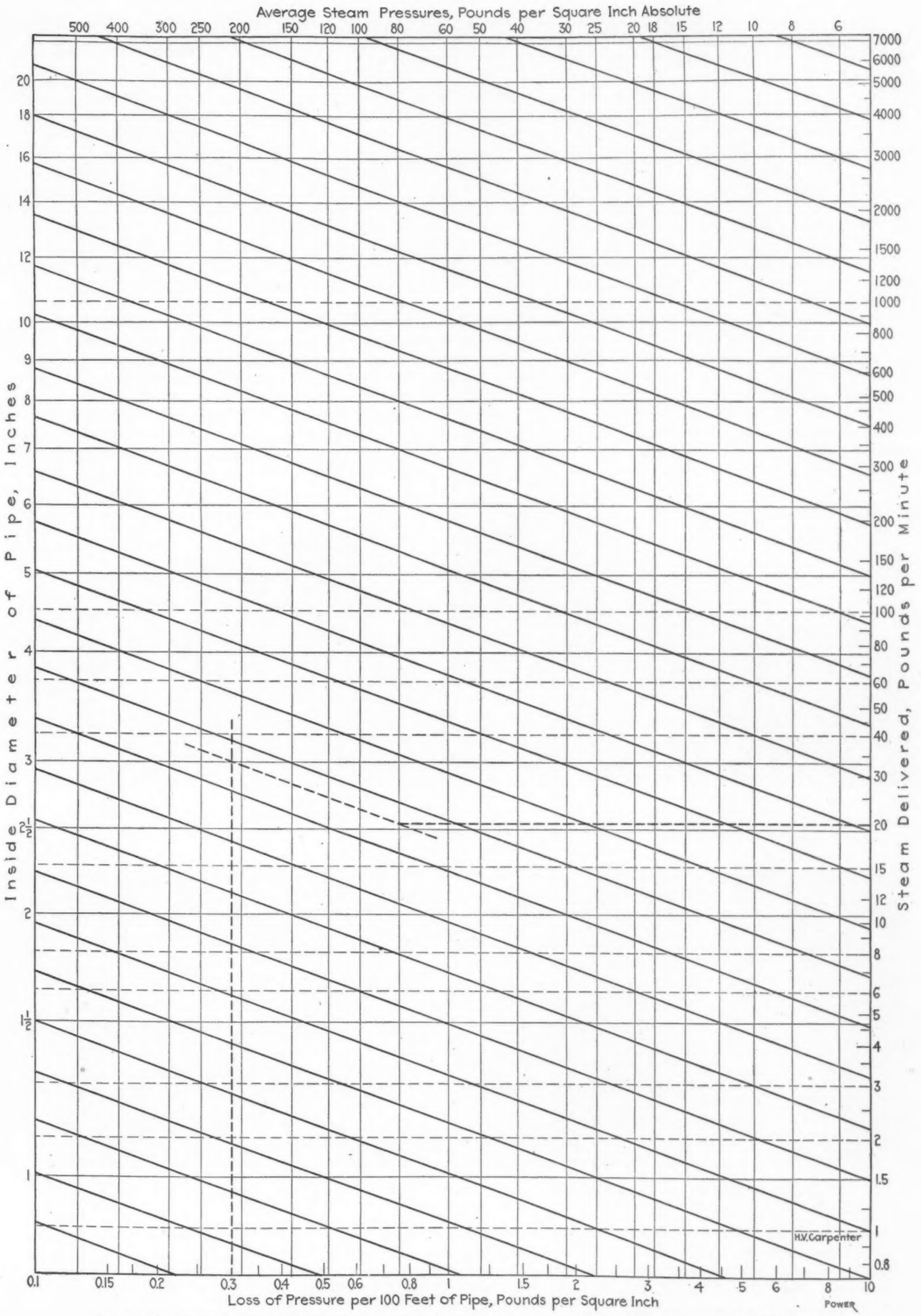


CHART SHOWING LOSS OF PRESSURE WHEN A GIVEN AMOUNT OF STEAM PER MINUTE IS DELIVERED THROUGH A PIPE OF GIVEN SIZE

In order to simplify the use of these formulas the accompanying charts are presented, the first representing the formula for V just given, and the second the formula for W. The velocity chart is given because many engineers have become accustomed to designing for an assumed velocity, usually about 6000 ft. per min. The chart shows the velocity which may be expected for any given set of conditions. For example, following the heavy dotted lines, a drop of 0.3 lb. per 100 ft. of pipe, in a 3-in. pipe, with an average pressure in the pipe of 80 lb. per sq.in., will give a velocity of 2380 ft. per min. Or, a velocity of 6000 ft. per min., with an average pressure of 250 lb. per sq.in., in a 10-in. pipe will require a drop of slightly over 1 lb. per 100 ft. of pipe. For the same conditions, however, with a 2-in. pipe the loss is more than 10 lb. per 100 ft.

These examples bring out the striking effect of the pipe size and the pressure on the loss, and show that the 6000-ft drop in pressure, and weight of steam passing per minute. For example, following the heavy dotted lines as before, with a loss of 0.3 lb. per 100 ft. in a 3-in. pipe at an average pressure of 80 lb., the quantity of steam delivered will be 21 lb. per minute. Or, with 1 lb. per 100 ft. drop a 10-in. line will deliver 860 lb. per min. when the average pressure is 60 lb. per sq.in., or a little over 1500 lb. per min. when the pressure is 200 lb. per sq.in. Or, if a 20-in. pipe is delivering 4000 lb. per min. at an average pressure of 250 lb. per sq.in., the drop in pressure will be 0.15 lb. per 100 ft. of pipe.

Regarding the accuracy of the charts, they represent the formulas exactly, except for the inaccuracies in drawing, and in reading the scales. These errors are far within the limits of accuracy needed in practice so the charts may be used with the same degree of confidence as the formulas.

As to the accuracy and range of the formulas, it seems that all of the published experiments were made with pipes of from 1.85 to 4 in. in diameter. There is little doubt that the formulas may be applied with entire safety over a much wider range than this, but the practical limits are unknown.

rule cannot be taken as safe or desirable where there is a very wide range of cases.

The second chart will ordinarily be found the more useful since it shows the relations existing among the essential quantities; size of pipe, average pressure,

Locomotive Boiler Explodes

By A. D. Nichols

A Colorado & Southern R.R. freight locomotive exploded recently while making a heavy grade, near Bunker Hill, Colo., killing the engineer and fireman.

The locomotive was an eight-driver consolidation type. The boiler was blown to one side of the track, as shown in Fig. 1, a distance of nearly 200 ft.

In Fig. 2 is illustrated a view of the boiler from the front end, showing the crown-sheet blown down through the firebox.

A close view of the crown-sheet and firebox is shown in Fig. 3. The initial rupture took place where the crown-sheet and flue sheet joined, making a clean tear in the sheet and leaving the riveted joint intact.

With but two exceptions the crown and side sheets stripped from the stay-bolts, leaving them in the outside sheets. To all appearances the cause of the trouble was low water. There was, however, a heavy coating of scale, in some parts an inch thick, on the crown-sheet. Fig. 4 is a view of the interior of the boiler taken from the firebox end. The flues were badly bent as were also some of the stays.

Fig. 1. Boiler Blown to One Side of Track

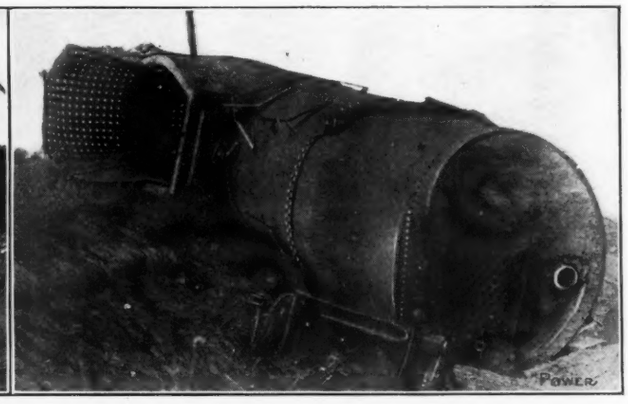


Fig. 2. Crown Sheet Blown through Bottom of the Firebox

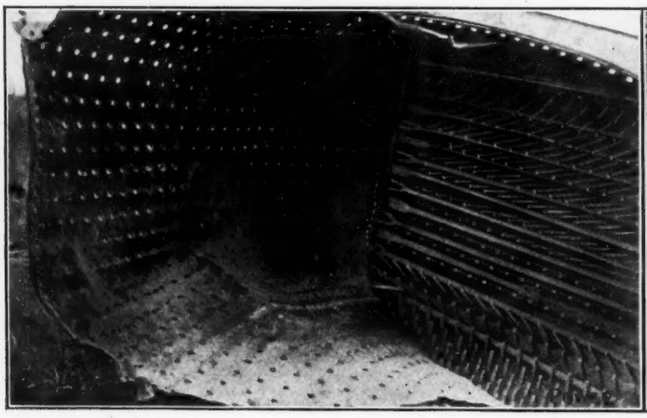


Fig. 3. Near View of Crown Sheet

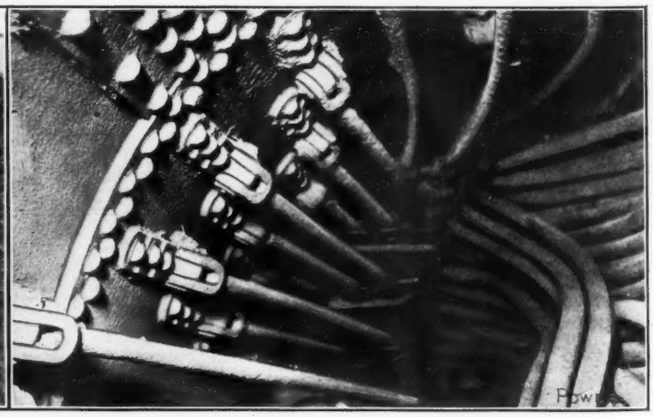


Fig. 4. Interior of Firebox

Importance of Furnace Efficiency*

By Joseph Harrington

Furnace efficiency is the controlling factor in combined efficiency and is independent of rate of combustion. A heat balance on the basis of coal as fired is necessary for a proper understanding of efficiency losses.

*Abstract of paper read before the Western Society of Engineers, Chicago.

The code of the American Society of Mechanical Engineers specifies the combined efficiency of boiler and grate as being the ratio of the heat actually used in converting water into steam, to the total amount of heat energy in a unit of dry coal, and until recently combined efficiency has been the basis for judging the performance of a boiler and furnace. It is proposed to illustrate the insufficiency of that kind of an analysis and to show that the efficiency of the elements themselves should be determined.

With the development of the modern mechanical stoker the process of burning coal is now considered the more important of the elements entering into the stoker-boiler unit. An inspection of the heat balance under the heading of "Boiler Losses," in the test-record sheet of the Green Engineering Co., will show three items. No. 61 is the heat loss due to the temperature of the gas above the temperature corresponding to the steam pressure. A study of Fig. 1 will show the rise in flue temperature corresponding to an increased boiler capacity. Inasmuch as the steam pressure was constant throughout these tests, it is evident that the rise in flue temperature is not proportional to the rate of combustion, or the developed capacity of the boiler. This signifies that the true boiler efficiency is not greatly affected by differences in the rate of heat absorption. Ability to absorb heat controls boiler efficiency, while furnace efficiency is affected by several considerations. The ability of a tube to transmit heat, when in a standard condition of cleanliness, is practically the same at all times under similar conditions.

The accompanying table shows half a dozen heat balances, which will indicate a fairly constant boiler efficiency at a fair range of ratings. The grate and furnace efficiency, however, vary to an appreciable extent.

For a proper appreciation of the disposition of the heat contained in a pound of fuel, the analysis must be on the heat contained in the fuel as it is actually fired, rather than upon the basis of either dry coal or combustible. What the engineer wants to know is how the heat contained in the actual coal he is firing is disposed of; and as the moisture contained in the coal has an influence on the efficiency of the entire process, it must be taken into consideration in an accurate analysis.

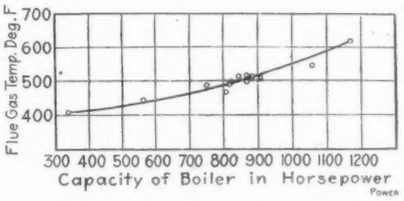


FIG. 1. RELATION BETWEEN BOILER CAPACITY AND FLUE GAS TEMPERATURE

The Middle Western coals will frequently contain as high as 15 per cent. of moisture, and lignites almost invariably carry from 25 to 40 per cent. In the latter case, a considerable portion of the total heat value of the coal is utilized in evaporating this moisture, which robs the boiler of just that much heat and reduces the net evaporation by that amount. Eastern coals exhibit the more accurate relation between the actual and dry analyses, but boiler tests with these coals should be analyzed on a basis of coal as fired just the same. The test sheet previously referred to takes into account the heat balance based on coal as fired, in which the actual heat in a pound of fuel is accounted for, the various losses being given in terms of British thermal units. An expression of these values in the form of percentages might perhaps give a clearer notion of the significance of the item. This test sheet has been developed in logical order, so that the various items can be figured in rotation, the data for the calculation of every item having been previously figured.

On account of the heat balances involving the ultimate analysis, some question may be raised as to the difficulty of obtaining this analysis in connection with an ordinary test. If the test is to be worked out in all its refinements, such analysis is essential, but it has been found that with a given coal, the ultimate analysis is so nearly constant that the heat balance is not affected materially by the slight variations that exist. If the exact origin of the coal can be established, an ultimate analysis can be easily determined. The United States Geological Survey has published a great many, identifying each analysis with a certain coal.

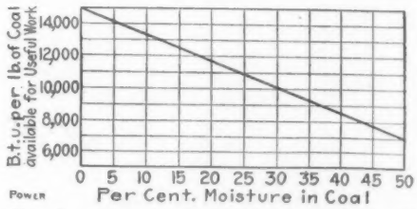


FIG. 2. EFFECT OF MOISTURE IN COAL ON AVAILABLE HEAT

In Fig. 2 is shown how moisture in the coal affects the heat available for useful work. This is plotted on the assumption that the net coal in a pound of fuel (disregarding ash for the time being, or considering the ash percentage constant) is the difference between the percentage of moisture and 100. For ex-

HEAT BALANCE PER POUND OF COAL FIRED-B.T.U.

	B.t.u. per pound	Absorbed by boiler: Water	Absorbed by boiler: Steam	Necessary Losses: Moisture and H_2O from H	Necessary Losses: By dry gases up to temp.	Necessary Losses: Available for unit	Necessary Losses: Highest theor. efficiency	Furnace and Grate Losses: Comb. in ash	Furnace and Grate Losses: Excess air to T_P	Furnace and Grate Losses: CO	Furnace and Grate Losses: Cinders	Furnace and Grate Losses: Available for boiler	Furnace and Grate Losses: Furnace and grate efficiency	Boiler Losses: By temp. gases above T_P	Boiler Losses: Air Leakage	Boiler Losses: Radiation and unacc't for	Boiler Losses: Boiler efficiency	Comb. efficiency
July 6, 1911..	11,027	9534	866	391	655	12,981	92.6	319	89	0	290	12,283	94.6	483	854	546	84.7	74.1
Jan. 18, 1912	13,092	8668	765	450	696	11,946	91.3	405	193	56	190	11,102	92.9	941	406	322	84.9	72.0
June 1, 1911..	14,103	9089	831	447	713	12,943	91.8	332	523	155	290	11,643	90.0	680	311	732	85.2	70.3
May 31, 1911	13,389	8557	803	427	667	12,295	91.8	557	339	121	290	10,888	89.4	576	196	856	85.2	69.9
June 15, 1911	13,370	8671	749	471	624	12,275	91.8	479	460	0	290	11,046	90.0	658	273	695	85.2	70.4
Jan. 29, 1912.	13,362	8706	734	487	707	12,168	91.1	594	175	110	290	10,999	90.4	424	349	786	85.9	70.7
July 6, 1911..								2.39	0.64	0.0	2.08		94.6	3.47	6.13	3.92	84.7	74.1
Jan. 18, 1912.								3.09	1.47	0.43	1.45		92.9	7.19	3.10	2.46	84.9	72.0
June 1, 1911..		Heat	balance	in per c	ent.			2.35	3.71	1.10	2.06		90.0	4.82	2.21	5.19	85.2	70.3
May 31, 1912								4.16	2.53	0.90	2.17		89.4	4.30	1.46	6.39	85.2	69.9
June 15, 1911								3.58	3.43	0.0	2.17		90.0	4.90	2.04	5.20	85.2	70.4
Jan. 29, 1912.								4.45	1.31	0.82	2.17		90.4	3.17	2.61	6.88	85.9	70.7

TEST RECORD SHEET

Report of Test on ..... Boilers Equipped With .....

Grates at ..... Owned by .....

Purpose of Test .....

Fired by ..... of ..... Date ..... 19 .....

1	Run from ..... to		11	Steam gage pressure ..... lb.	
2	Duration of test		12	Atmospheric pressure ..... lb.	
3	No. of boilers used		13	Absolute steam pressure ..... lb.	
4	Type of boiler		14	Draft suction at uptake ..... in.	
5	No. of tubes		15	Draft suction over fire ..... in.	
6	Diameter of tubes		16	Draft pressure under fire ..... in.	
7	Water heating surface ..... sq.ft.		17	Average temperature boiler room ..... deg.F.	
8	Superheating surface ..... sq.ft.		18	Average temperature flue gases ..... deg.F.	
9	Grate surface ..... sq.ft.		19	Average temperature feed water ..... deg.F.	
10	Ratio grate surface to water heating surface ..... 1 to		20	Average temperature steam Tp ..... Ts ..... deg.F.	

21	Name of fuel	
22	Size of fuel	

Proximate Analysis						Ultimate Analysis			Ash		Flue Gas			
H_2O	V.M.	F.C.	Ash	S	B.t.u. Per Pound	C.	H.	S.	% Comb. in Refuse	Refuse % Coal Fired	CO_2	O	CO	N. etc.
					Fired ..... Dry ..... Comb					Refuse % Dry Coal	1st Pass ..... Flue			

23	Coal burned total run actual ..... lb.			Heat Balance per Lb. Coal Fired	
24	Coal burned per hour actual ..... lb.		48	Heat per lb. Coal fired ..... B.t u.	
25	Coal burned per hour dry ..... lb.		49	Heat absorbed by water in boiler ..... B.t.u.	
26	Coal burned per hour per sq.ft. grate surface actual ..... lb.		50	Heat absorbed by steam in boiler (superheat) ..... B.t.u.	
27	Total weight of refuse ..... lb				
28	Total weight of combustible ..... lb.			Necessary Losses	
29	Water evap. total run actual ..... lb.		51	Heat absorbed by moisture and H_2O from burned H up to Tp ..... B.t.u.	
30	Water evap. per hour actual ..... lb.		52	Heat absorbed by theoretical amt. dry gases up to Tp ... B.t.u.	
31	Factor of evaporation		53	Heat available for unit ..... B.t.u.	
32	Water evaporated per hour (f. & a 212 deg.) ..... lb.		54	Highest theoretical efficiency ..... %	
33	Quality of steam ..... %				
34	Horsepower builder's rating			Furnace and Grate Losses	
35	Boiler horsepower (Mean of Test)		55	Heat loss due to combustible in ash ..... B.t.u.	
36	Boiler horsepower (Max. hr.)		56	Heat absorbed by excess air up to Tp ..... B.t.u.	
37	Per cent. rating (Mean of Test)		57	Heat loss due to production of CO ..... B.t.u.	
38	Sq.ft. water heating surface per hp. (Mean of Test)		58	Heat loss due to production of cinders ..... B.t.u.	
39	Water evaporated actual per lb. coal as fired, ... lb.		59	Heat available for boiler ..... B.t.u.	
40	Water evaporated actual per lb. dry coal ..... lb.		60	Furnace and grate efficiency ..... %	
41	Water evaporated f & a 212 deg. per lb. coal as fired ..... lb.				
42	Water evaporated f & a 212 deg. per lb. dry coal ..... lb.			Boiler Losses	
43	Water evaporated f & a 212 deg. per lb. combustible ..... lb.		61	Heat loss due to temp. of gases above Tp ..... B.t.u.	
44	Wt. of gas per lb. Coal Fee ..... lb. Flue ..... lb.		62	Heat loss due to air leakage through boiler setting ..... B.t.u.	
45	Percentage of excess air Fee ..... % Flue ..... %		63	Heat loss due to radiation and unaccounted for ..... B.t.u.	
46	Cinders, (a) weight ..... (b) % coal fired		64	Boiler efficiency ..... %	
47	Carbon in Cinders per cent. coal fired ..... %		65	Combined efficiency ..... %	

Ta = Temp. of air in boiler room.

Tp = Temp. corresponding to steam pressure.

Tf = Temp. of gases in flue.

Cb = Carbon burned per lb. actual coal

Sp. Ht = Specific heat of the steam.

Ts = Temp. of steam as superheated.

Hs = Total heat in superheated steam.

Ht = Total heat in dry steam at observed pressure.

ample, wet coal containing 20 per cent. of moisture would contain only 80 per cent. of combustible. In this way, the diagram has been worked out within the range of ordinary moisture content. Lignite coals often contain 35 per cent. of moisture, which would mean 9350 B.t.u., instead of 15,000 if the coal had not contained any moisture.

Add to the losses due to the moisture contained, the unavoidable losses due to combustible in refuse, the losses due to excess air, the losses due to radiation and unaccounted for, and the other losses which may be charged against the particular method of operation in vogue, and a point will very soon be reached where a wet coal ceases to be of any value. It has been found by experimentation that a moisture content of 25 per cent. is about the limit of practical usefulness with the ordinary form of furnace in commercial service. Lignites carrying moisture in excess of this, require a specially designed furnace wherein the heat generated by the combustion of the fixed carbon can be more efficiently brought into contact with the incoming fuel.

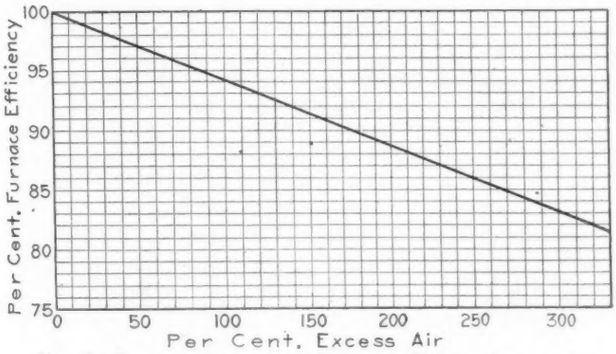


FIG. 3. RELATION BETWEEN FURNACE EFFICIENCY AND EXCESS AIR

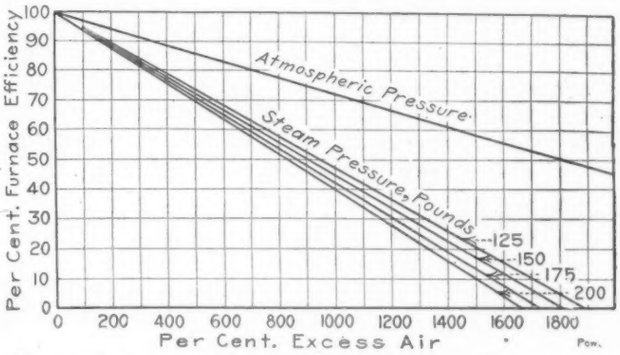


FIG. 4. EFFECT OF EXCESS AIR ON FURNACE EFFICIENCY AT DIFFERENT STEAM PRESSURES

In addition to the influence of moisture, furnace efficiency is affected by the amount of air used in burning the fuel. In many cases with Western fuels, a gas analysis of 10 per cent. of CO_2 would be considered fair practice. To maintain this figure, a fairly uniform fuel bed is required, and there must not be frequent or extensive opening of firing doors for stoking or slicing. A gas analysis of 13 per cent. of CO_2 is about the limit of economical operation with Western coals, because when the CO_2 is carried much beyond this point, CO will develop and the furnace efficiency on this account will not increase, the loss due to imperfect combustion being greater than the gain effected by reducing the excess air. A study of these various effects is given in Figs. 3 and 4.

In Fig. 3 is shown the effect on furnace efficiency of an excess of air. This curve has been carried to the ordinary extent of dilution, and illustrates the result of a leaky fuel bed or porous setting.

Fig. 4 shows the effect of varying steam pressure on the relation between furnace efficiency and excess air. This is not materially important, but it is interesting to notice that the lower the steam pressure, the less is the detrimental effect of excess air.

The design of the furnace to effect the necessary mixing, varies widely with different fuels and drafts and rates of combustion, and in the absence of any means for determining this mathematically, it appears to still remain largely a question of experience. The product of incomplete combustion is CO, wherein only about one-third of the potential heat is developed. It is, therefore, obviously important that CO must not be present in appreciable amounts.

It has been stated that there are other hydrocarbon compounds which are present in flue gases and which are carried away with the escaping gases whenever CO is present. These gases, not being of such a nature as to render it possible to detect them by the usual means, have added an element of uncertainty in the ultimate analysis of efficiency losses.

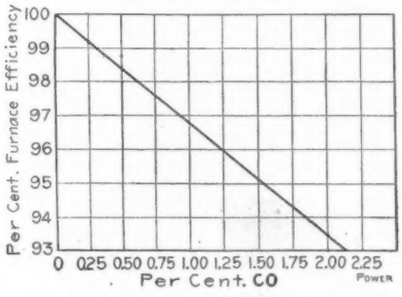


FIG. 5. RELATION BETWEEN FURNACE EFFICIENCY AND LOSS FROM CO

The author's experience, in analyzing a large number of heat balances, is that the presence of these intangible combustible compounds is quite apparent. A portion of the heat unaccounted for is undoubtedly due to this. It is doubly important, therefore, that CO in furnace gases should be held down to an absolute minimum. It is not always the case that heavy reduction in air excess must be secured before CO will appear. This is largely a question of the proper mixing in the furnace which is dependent on the size and design of the combustion space. Both CO and excess air may be present at once and the extent of this is purely a question of the capacity of the furnace to mix and retain the gases until the combustion is complete. It is, however, our experience that when CO appears, it is time to stop the reduction of air supply, even though it is quite obvious that the mixing ability of the furnace is deficient. Fig. 5 illustrates the effect of CO on furnace efficiency.

In connection with the paper the author gave the mathematics showing the method of determining the excess air and CO curves. The deductions therefrom are that each 100 per cent. of excess air affects the efficiency 5.62 per cent., and that each 1 per cent. of CO reduces furnace efficiency by 3⅓ per cent. If this were carried to the ultimate, the efficiency would be zero when the per cent. of CO reached 30, assuming that such was possible.

Lunkenheimer "Puddled" Semi-steel Valves

To meet the demand of high pressures and superheated steam, the Lunkenheimer Co., Cincinnati, Ohio, has got out a line of "puddled" semi-steel valves.

This metal is an extremely high-grade iron and steel alloy with an average tensile strength of 35,000 lb. The valves are made in two combinations C and D, to suit various conditions of superheat and to meet the specifications of engineers who differ as to the metal that should be used in the trimmings. Combination C is guaranteed for a temperature of 600 deg. F. and D for 550 deg. F. Both combinations are suitable for 250 lb. pressure per sq.in.

An English company holding a concession in Russia for constructing a hydro-electric station on the River Terek has under advisement constructing a tramway system to connect Vladikavkaz with Nalchick and Kislovogsk.

Eynon-Evans Blowoff Valve

A new type of blowoff valve is shown herewith, consisting of a yoke and body cast in one piece, Fig. 2. A nickel ring *B*, Fig. 1, is secured in the iron body, the interior diameter of the ring being the same as that of the bronze shield *C*, thus forming a continuous surface to receive the packing ring *D*. This ring is so placed in the ring *B* and shield *C* that it prevents leakage from the inlet to the outlet of the valve, and around the stem *E*. It can be adjusted or compressed by the nuts *F* to the desired density while the valve is in service.

The handwheel *G* withdraws the pistons *H* and *J* with the packing from the ring *B* into the shield *C*. The latter is operated by the handwheel *K*. This construction draws the packing into the shield before any grit, scale or other foreign matter is permitted to pass through the valve from the boiler. The lower end of the shield also acts as a valve and permits removing and inspecting the packing while the blowoff valve is in service under full water pressure.

The valve is really two-in-one, and when operated the wheel *G* is rotated, causing the packing *D* and piston *H* to rise or open until the shoulder on the follow-up piston *J* strikes the bottom of the hub *L*. The packing *D* is thus inside the shield *C* and fully protected from injury. Rotating the wheel *K* causes the shield *C* to rise until the shoulder just below the threaded section strikes the bottom of the bushing *M*. In this position the lower valve is wide open. Fig. 3 shows the valve partly open. In closing the valve the shield *C* is screwed in until it strikes the seat *B*, when the handwheel *G* is turned, forcing the packing *D* and piston *H* to the position shown in Fig. 1.

This valve is manufactured by the Eynon-Evans Manufacturing Co., Fifteenth and Clearfield streets, Philadelphia, Penn.

New Mechanical and Electrical Time Recorders

The Industrial Instrument Co., Foxboro, Mass., has added to its line of recording instruments, a mechanical time recorder, or operation recorder. The instrument is mounted in a round form of case. The pen arm is attached to and supported by a shaft or axis. An arm attached to the shaft passes through the case and an extension with adjustable clamps serves to facilitate the adjustment of the available motion to secure the desired pen travel on the chart. Clock movements are supplied to revolve the charts in 10 and 30 min., 1, 2, 3, 4, 6, 12 and 24 hours and seven days as desired.

The recorder is useful in recording the frequency, duration and extent of any mechanical motion, such as opening and closing of gates, valves or doors, etc.

An electrical time recorder has also just been placed on the market by the same company. It is operated by electric contact and consequently is adapted for use in many places where it is desirable to put the recorder at a distance from the source of motion or operation. When contact is made the current actuates an armature to which the pen arm is attached and the chart records the frequency and duration of contact. These electrical time recorders are regularly supplied with any number of pens up to six for recording independent operations simultaneously on the same chart.

Our Vast Coal Reserve

The known coal fields of the United States embrace a total area, according to the United States Geological Survey, of 310,296 square miles, to which may be added something over 160,000 square miles of which little is known, but which may contain workable coals, and about 32,000 square miles where the coal lies under heavy cover and is not considered available under present conditions. The supply of coal before mining began is estimated to have been 3,076,204,000,000 short tons, of which 1,922,979,000,000 tons were considered to be easily accessible and 1,153,225,000,000 short tons to be either so deep or the beds so thin that they are accessible only with difficulty. Classified according to the character of the coal, the original supply consisted of 21,000,000,000 short tons of anthracite,

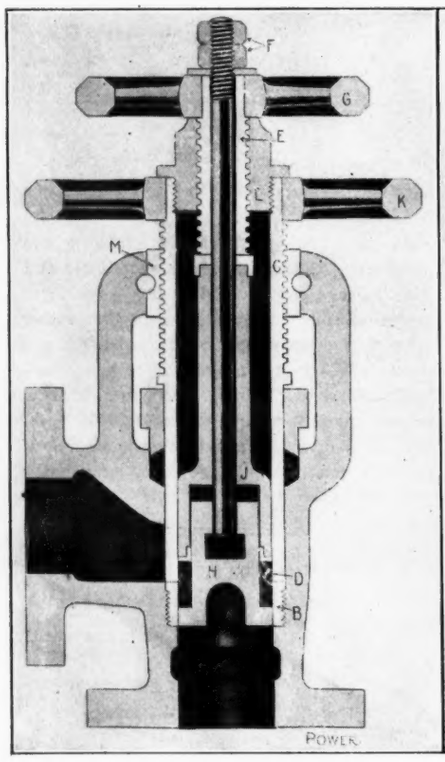


FIG. 1. VALVE CLOSED

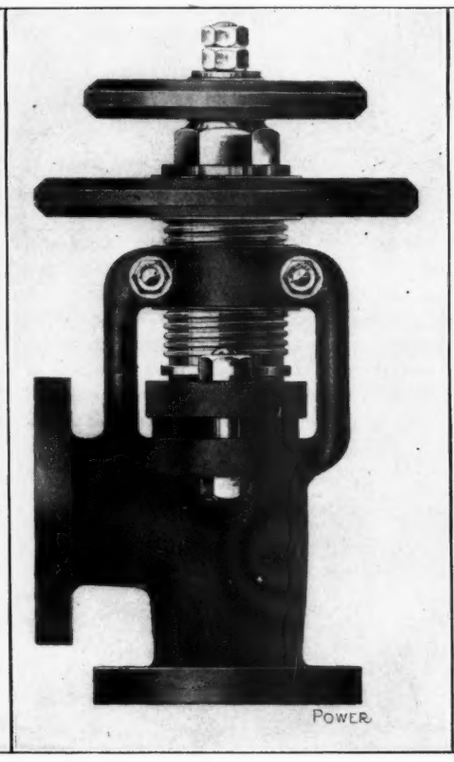


FIG. 2. EXTERIOR VIEW

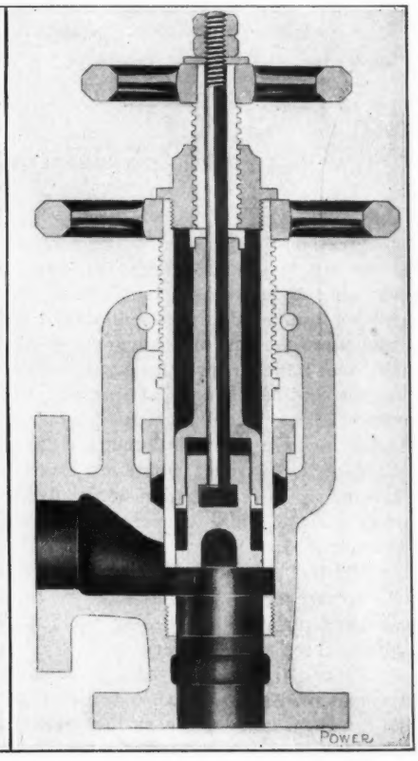


FIG. 3. PARTLY OPEN

1,661,457,000,000 tons of bituminous coal, 650,157,000,000 tons of sub-bituminous coal, and 743,590,000,000 tons of lignite.

The total production of coal to the close of 1911 has amounted to 2,270,798,737 short tons of anthracite and 6,468,773,690 tons of bituminous coal, or an aggregate of 8,739,572,427 tons. This total production to the close of 1911 represents, including the waste of coal in mining, an exhaustion of the beds equal to 14,181,980,000 short tons, or somewhat less than 0.5 per cent. of the original supply. In other words, the quantity of coal still remaining to be mined amounts to 3,062,022,020,000 short tons, or a little more than 99.5 per cent. of the original supply. The annual rate of exhaustion at the present time as represented by the production in 1910 and 1911 is 0.025 per cent. of the supply. The quantity of coal still in the ground at the close of 1910 was 6000 times the production of that year, or, estimating a half ton of coal lost for every ton recovered, the supply is equivalent to 4000 times the present annual rate of exhaustion.

Injector Troubles and Their Remedies

By R. Ewart Cleaton

These troubles are often due to scaled tubes and leaking pipes and joints. Many of them are designated and the remedy given, also the method of testing for leaks.

As the proximity of heat is detrimental to a vacuum, an injector should be placed well away from the boiler; the steam connection should be at least 9 or 12 in. long from the boiler shell. If the injector still gets warm, a hose played upon it will remedy the troubles temporarily, and a piece of asbestos millboard placed between the boiler and the injector, will also serve to keep the latter cool. The steam outlet should be connected to a high point of the boiler to insure a maximum amount of dry steam.

In most portable plants, the water supply is obtained on a lift, and care should be taken that it is not greater than that for which the injector is designed; the shorter the better, as the longer the lift the greater is the decrease in the capacity of the injector.

Water Supply

One of the most common causes of trouble arises from a dirty water supply. This can be obviated in several ways. Where the water contains a large amount of suspended matter, the use of a settling tank is advisable, from which the water can be drawn off into another tank, or, as is more often the case on contractors' plants, a barrel into which the suction pipe is introduced.

Care should be taken to see that fibrous, scaly or greasy matter adhering to the sides, is removed before inserting the suction pipe, and that the end of the latter is 12 to 18 in. from the bottom. This is especially desirable when a settling tank is not employed, for should it be only 2 or 3 in. above the bottom of the barrel the force of the suction will cause the mud to be drawn into the injector.

The suction pipe should have a fine-mesh brass or copper strainer to arrest any suspended substance in the water. A foot valve will also materially add to the ease of starting. Should the mesh become dirty and clogged, it can be cleaned by blowing a jet of steam through it, previously disconnecting the foot valve from the suction pipe.

Having made sure of a clean water supply, next in importance is the piping.

Piping

Half the trouble experienced with injectors may be attributed to either using the wrong sort of piping, or defective material.

Rubber piping should be avoided entirely, as it deteriorates very rapidly, and small pieces of rubber are detached, thereby undoing all the good that has been obtained by insuring a clean water supply. Galvanized-iron pipe should be used in preference to ordinary black pipe, as the chance of rust forming and detaching itself is eliminated. Fittings, such as elbows, etc., should be curved, not square, and preferably of malleable iron instead of cast iron, as a better thread can be obtained, thus insuring tighter connections and consequently preventing leaks.

An easy way to locate a leak in the piping is to plug up the suction end of the pipe as tightly as possible, open the water-regulating valve to its full extent having also wedged the overflow valve on the injector so that it will not open, and then turn on the steam; any leak will be plainly discernible by the jet of escaping steam. Assuming that the piping system is perfect, it will often be found that the gland in one of the valves is defective and requires repacking. Unless every gland and joint in the entire system is perfectly tight, the injector cannot be expected to give satisfaction.

When the plant is in a district having a chalky or limestone subsoil, a great deal of lime is bound to be in solution in the water, and when steam is raised this is precipitated not only in the boiler, but also in the pipe conveying steam to the injector. This in time will cause serious obstruction to the steam, thereby diminishing its velocity to a large extent, which in turn will lessen the vacuum necessary for the working of the injector. When this happens, the pipes affected should be disconnected and allowed to soak in a 10 per cent. solution of muriatic acid, for at least 12 hr. This can be done over night, and not delay the working of the plant in the daytime.

An injector will not work efficiently, with the steam passing through a pipe smaller than the inlet nozzle, and this is the condition when the pipes become encrusted with scale. The suction and feed pipes should also be the same size as the injector connections.

A priming boiler is another common cause of trouble, as water or oil in the steam supply will destroy the necessary vacuum.

Valves

The valves should be brass, of the globe type in preference to the straight-way. Special care should be taken in connecting up the check valve on the feed line between the injector and the boiler. Although this may appear extremely simple, trouble is often caused by this valve being carelessly put wrong end on. If this is done no rectification of the other defects will enable water to be forced into the boiler. If the overflow valve continuously leaks when the injector is working, it should be reground with a little flour of emery.

Capacity

The capacity of an injector is affected in many ways, such as the distance the water has to be lifted, if the supply is below the injector; the height above the injector, if the water is taken from an overhead tank; the temperature of the water supply; water pressure, if taken from a main, and the steam pressure. These conditions should be considered when buying an injector and the makers consulted as to the most suitable size. Besides stating the above, the size of boiler used should also be given.

To test the capacity of an injector, close the globe valve between the boiler and the check valve in the delivery pipe and take off the cap of the check valve and remove the check. Then place a pail under the valve and allow the injector to run for exactly one minute, timing it with a watch. The amount thus collected in the pail multiplied by 60 will then give the hourly capacity of the injector in gallons.

When to Install a Fuel Economizer

By Everard Brown

Figures are given in an assumed case showing the gain that may be expected, with fuel at different prices, by installing an economizer. Other advantages are also shown.

Under what conditions it is advisable to include a fuel economizer in the design of a new power plant is a problem demanding careful consideration. A general assumption is that for every increase of 10 deg. in the feed-water temperature 1 per cent. in fuel will be saved and, as the function of an economizer is to raise this temperature, it is sometimes assumed that the fuel saving of 1 per cent. will hold good under all conditions. This is not the case, however, as will be shown.

Assume an ordinary boiler plant of 1000 hp. operating under 150 lb. steam pressure at its rated capacity, the flue gases escaping at 600 deg. F. and the feed water entering the economizer at 150 deg. The average coal consumption for everyday practice is, say, 4 lb. per boiler horsepower, which corresponds to an evaporation of approximately 8.5 lb. of water from and at 212 deg. Running 24 hours per day, six days per week and 50 weeks per year, the coal consumption will be

$$\frac{4\times 24\times 6\times 50}{2000} = 14.4 \textit{ net tons of coal per b.hp.}$$

Under these conditions it may be assumed that any good economizer will easily raise the temperature of the feed water 100 deg. so that the percentage of heat gained will be,

Water entering economizers at 150 deg. contains 117.9 B.t.u. above 32 deg. F.,

Water leaving economizer at 250 deg. contains 218.5 B.t.u. above 32 deg. F.,

Steam at 150 lb. gage pressure contains 1193.4 B.t.u. above 32 deg. F.

$$\frac{218.5 - 117.9}{1193.4 - 117.9} = 9.35 \textit{ per cent. heat gained}$$

By taking 9.35 per cent. of 14.4 net tons of coal burned per boiler horsepower per year, the gross fuel saving is 1.35 net tons per boiler horsepower per year or 1350 tons for 1000 boiler horsepower.

From this saving must be deducted all charges incident to the operation of the economizer as well as interest on the investment. Under ordinary conditions a good economizer can be installed for about $6.50 per horsepower. This figure includes the apparatus itself, foundations, piping, flues and the increased height of stack necessary for an induced draft system.

These charges may be segregated as follows:

Interest on investment	5 per cent.
Depreciation (assuming life of apparatus to be 20 years)	5 per cent.
Repairs and maintenance	2 per cent.
Attendance	2 per cent.
Power for operating scrapers and increased pumping head due to economizer	3 per cent.
Miscellaneous	2 per cent.
Total	19 per cent.

On an investment, therefore, of $6500, the estimated cost of a 1000-hp. plant, the total charges would be $1235, which must be deducted from the gross saving of 1350 tons of coal. Assuming, then, that coal can be obtained for $1 per ton, the gross saving would be $1350, from which must be deducted $1235, thus leaving a net saving of $115, which is only 1.77 per cent.

At the following prices of coal the savings on the investment would be:

Cost of coal per ton	Gross savings	Net savings	Per cent. interest on investment
$1.00	$1350.00	$115.00	$1.77
2.00	2700.00	1465.00	22.54
3.00	4050.00	2815.00	43.30
4.00	5400.00	4165.00	64.00

On a basis of a 10-hour day for the same number of days per year as the foregoing, the results would be:

Cost of coal per ton	Gross savings	Net savings	Per cent. interest on investment
$1.00	$562.50	$380.00 loss	5.84 loss
2.00	1125.00	182.50	2.80
3.00	1687.00	745.00	11.46
4.00	2250.00	1307.50	20.11

These figures are based on a total charge against the economizer of 14.5 per cent. obtained by dividing each of the percentages for repairs, attendance, power and miscellaneous by two, but leaving those for interest and depreciation stand, as they would naturally be the same whether the plant operated 10 hours per day or 24.

Such an installation may be considered typical as to what can be expected of a fuel economizer and, while there is probably no actual condition where this example will apply as given, nevertheless, it may be used as a guide and, by the proper substitution of figures for a particular plant, a fairly accurate idea can be obtained as to the results that should follow. As the temperature of the feed water increases or the flue-gas temperature decreases, the advantages of an economizer diminish.

For ordinary practice the general statement may be made that an economizer will be a paying investment where the price of coal is over $2 per ton and where the flue-gas temperatures are over 500 deg. F., or, say, about 100 deg. more than the temperature of the steam within the boiler. It must be borne in mind, however, that often high temperatures of escaping gases may be attributed to the improper proportion of grate to heating surfaces, etc., which might be remedied so as to bring about a considerable saving without installing an economizer.

In considering a fuel economizer only one saving can be readily calculated, the saving in fuel. There are several other advantages, however, that strongly favor its installation under suitable conditions. For example, it will increase the capacity of the boiler plant from 10 to 20 per cent., according to the rate of evaporation per square foot of heating surface in the boiler and, because of the relatively large amount of reserve heat that the economizer is capable of storing, excessive peak loads can be carried more easily.

The life of the boiler is prolonged because the temperature of the feed water may be raised to that of the steam within the boiler, thereby minimizing the excessive strains resulting from unequal expansion and contraction. Also, because of this comparatively high temperature of the feed water, considerable scale-forming matter in the water is precipitated and can be blown off at the economizer; consequently the boiler will be cleaner and have a more efficient heating surface. While it is rather difficult to determine in dollars and cents just how great these advantages are; nevertheless, they should receive proper attention and be added to the saving effected in fuel when making a decision.

After a decision is reached favorable to installing an economizer, it should be remembered that the shortest and least impeded route into the economizer makes for not only greater efficiency but also less draft requirements. It is also important that the economizer tubes be kept clean both inside and out, as the same principle applies as with the boiler.

There were only two engine failures on the Oklahoma division of the Santa Fé R.R. in June, according to a newspaper report. Neither failure was the fault of the boiler department, but happened in the machinery; and both failures were unavoidable. This is probably the best record on the system. It is due to the team work that is in constant practice by the employees of the Santa Fé shops in Arkansas City. In April and June there were no boiler failures charged to the Oklahoma division, and this is a brilliant piece of work that is rarely accomplished on any division of the Santa Fé, if it is accomplished at all. —*The Boiler Maker.*

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Primer of Electricity

By Cecil P. Poole

Motor Field Windings

Three general classes of field windings are used on electric motors; shunt, series and compound. The compound field winding is of two kinds, "cumulative" and "differential." These are clumsy words, but the only ones that describe the windings accurately.

The shunt winding is connected across the brushes, as illustrated in Fig. 108. Consequently, it is subjected to the full electromotive force of the supply circuit. Shunt-wound motors are supplied always from constant-potential circuits.

The series field winding is connected directly in series with the armature, as indicated by Fig. 109. Consequently, the full armature current passes through the field winding, except under special conditions when part of the current is "shunted" out of the field winding by a wire or other conductor, as in Fig. 110. Series-wound motors may be used on either constant-potential or constant-current supply circuits, but they are almost always supplied from constant-potential lines.

A compound field winding consists of a shunt winding and a series winding, as represented by Fig. 111. In almost all cases compound windings for motors are of the "cumulative" kind; that is, both of the windings magnetize the cores in the same direction. In a "differential" winding the series winding opposes the shunt winding, but it is much weaker and therefore does not neutralize the shunt winding entirely.

Fig. 112 illustrates the principle of the differential winding. The coil *Sh*, consisting of, say, 30 turns, when excited by its normal current will magnetize the core *C* with the polarity indicated by the letters *N, S*. The coil *D* when excited by its normal current will magnetize the core in the opposite direction. If the current in the coil *Sh* be 2½ amperes, that coil will have a magnetizing force of $2\frac{1}{2} \times 30 = 75$ ampere-turns. If the current in the coil *D* be 5 amperes, its magnetizing force will be $5 \times 3 = 15$ ampere-turns; these will neutralize 15 ampere-turns of the 75 in the coil *Sh* and leave 60 to act on the core, which will be magnetized with the polarity *N, S*, but not so strongly as it would be if the coil *D* were absent or unexcited.

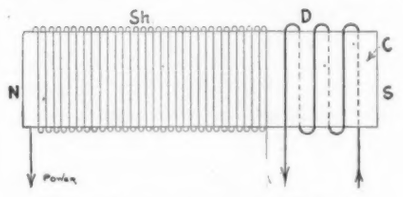


Fig. 112. Differential Winding.

The Shunt-wound Motor

Shunt-wound motors, supplied from constant-potential circuits, are used for general service where no special requirements exist. They run at almost constant speed at all loads because the field excitation and the impressed electromotive force are practically constant. The absorbed impressed electromotive force.

A shunt-wound motor operating on a constant-potential circuit has practically constant field flux because the field winding is connected directly to the constant-potential circuit, as illustrated in Fig. 113. The number of armature wires, of course, is constant. The counter electromotive force is equal to the impressed electromotive force minus the drop in the armature circuit:

C.e.m.f. = Imp. e.m.f. — drop

Consequently, any increase in the armature current will cause a decrease in speed, because it increases the drop in the armature circuit and thereby reduces that part of the impressed electromotive force that must be opposed by the counter electromotive force.

An increase in the armature current is caused automatically by an increase in the load on the motor. The reason is

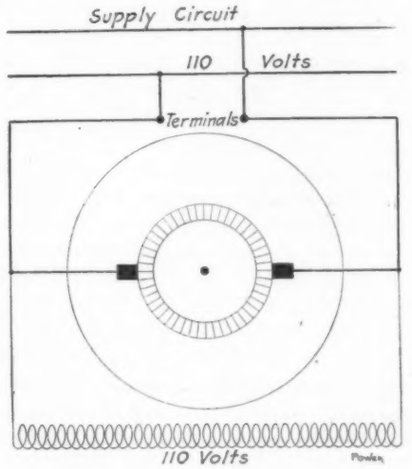


Fig. 113. Elementary Connections of Shunt-wound Motor

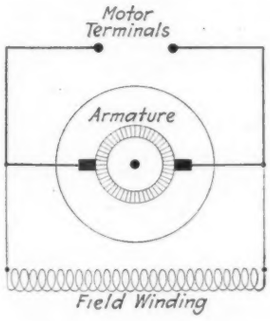


Fig. 108. Shunt-wound Machine

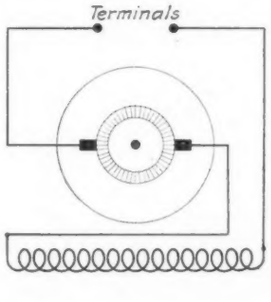


Fig. 109. Series-wound Machine

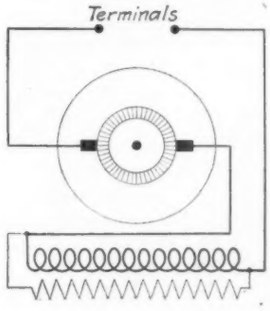


Fig. 110. Shunted Series Field Winding

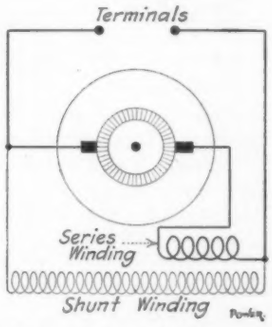


Fig. 111. Compound-wound Machine

that increasing the load tends to stop the armature, and the rate of speed is reduced until the counter electromotive force falls to a point where it allows the passage of enough current to equal the backward "pull" of the load. Here is where "torque" comes in.

For example, suppose a 110-volt motor had a total field flux of 2,500,000 maxwells (magnetic lines of force), an armature winding of 360 wires connected in two paths and an armature resistance of ¼ ohm. Also assume that the power required to drive the armature alone, without doing any external work, was such as to take 2 amp. from the supply circuit. The drop in the armature circuit at no load would be

$$\tfrac{1}{4} \times 2 = \tfrac{1}{2} \text{ volt}$$

leaving 109½ volts to be balanced by counter electromotive force. The speed at no load, therefore, would be

$$\frac{6{,}000{,}000{,}000 \times 2 \times 109\tfrac{1}{2}}{2{,}500{,}000 \times 360} = 1460 \text{ r.p.m.}$$

Now suppose a load were thrown on the motor which increased the backward drag to a torque of 9½ lb.-ft. With the current of 2 amp., which passed through at no load, the torque of the armature would be

$$\frac{2{,}500{,}000 \times 360 \times 1}{852{,}230{,}000} = 1.056 \text{ lb.-ft.}$$

which could not keep the speed up against the load torque of 9½ lb.-ft. The armature speed, therefore, would be pulled down by the excessive drag of the load; but as soon as the speed began to fall, the resultant fall of the counter electromotive force would allow more current to flow, thereby increasing the armature torque. When the speed diminished to 1437½ r.p.m. there would be no further decrease because the armature current would have increased to 9 amp., producing enough torque to balance the load drag. Thus, the counter electromotive force at 1437½ r.p.m. would be

$$\frac{2{,}500{,}000 \times 360 \times 1437\tfrac{1}{2}}{6{,}000{,}000{,}000 \times 2} = 107\tfrac{3}{4} \text{ volts}$$

leaving 2¼ volts to be taken up by resistance. The resistance being ¼ ohm, the current would be

$$\frac{2\tfrac{1}{4}}{\tfrac{1}{4}} = 9 \text{ amp.}$$

The torque produced by 9 amp., under the conditions described, would be

$$\frac{2{,}500{,}000 \times 360 \times 9}{852{,}230{,}000} = 9\tfrac{1}{2} \text{ lb.-ft.}$$

From this example it is evident that a shunt-wound motor supplied from a constant-potential line alters its speed automatically when the load changes, the speed variation being opposite to the load variation and just enough in extent to cause the armature current to increase or decrease to the exact value demanded by the load. It is also evident that the speed of such a motor does not vary in proportion to the load variation, the speed change being very much smaller than the load change. In the case just cited, for example, the speed dropped only 22½ revolutions in 1460, or 1½ per cent. in order to take care of a load increase of more than 200 per cent.

Starting a Shunt-wound Motor

When the armature of a motor is at standstill, the only opposition to the flow of current from the line is the resistance of the armature circuit. In the case just considered, if the motor were connected

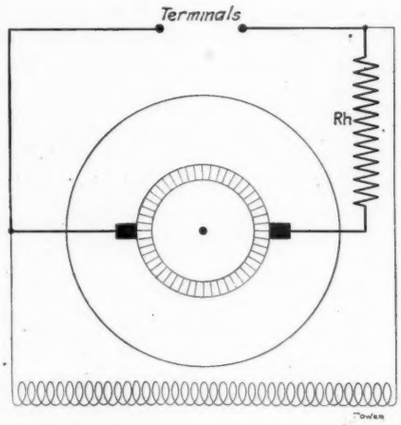


Fig. 114. Elementary Connections Including Starting Resistance

directly to the line while motionless, there would be an enormous rush of current through the armature. The resistance being only ¼ ohm, the tendency would be for a current of

$$\frac{110}{\tfrac{1}{4}} = 440 \text{ amp.}$$

to rush through. It takes time, however, for the current to reach the maximum value determined by the electrical resistance of a circuit. In the case of the motor, therefore, the armature would start with a tremendous jerk and begin generating counter electromotive force before the current reached 440 amp., but the rush would undoubtedly rise to between 300 and 400 amp. before the armature got under way.

To prevent such excessive current rushes, a shunt-wound motor is provided with an auxiliary apparatus commonly termed a "starting box"; the correct name is "starting rheostat." A starting rheostat consists of a few coils of wire —usually of iron—mounted on noncombustible insulators and arranged so that the wire can be cut out of circuit, section by section. This is connected in series with the armature of the motor as illustrated by Fig. 114, where *Rh* is the wire of the starting rheostat. When the connections between the armature and the supply circuit are first closed, all of the rheostat wire is in circuit, and its resistance is high enough to prevent a heavy rush of current through the armature, even if the latter should be prevented from revolving. For example, if the full-load armature current of a 250-volt motor is 25 amp., the resistance of the starting rheostat should be not less than 5 ohms, and would preferably be about 8½ ohms. With a 5-ohm rheostat the current rush would be slightly less than 50 amp., because the resistance of the armature winding and connections is added to that of the rheostat, making the total resistance slightly more than 5 ohms.

The usual method of cutting out the starting rheostat is illustrated in Fig. 115. A pivoted arm *A* is arranged to swing over a row of contact buttons located on the arc of a circle and connected to the resistor* *Rh* as shown. A contact finger on the end of the arm rubs on the faces of the contact buttons. When the circuit between the motor and the supply line is first closed, current flows through the field winding but not through the armature, because the arm is not in contact with any of the buttons. The arm is then moved to the first button, thereby closing the armature circuit through the whole resistor. When the armature has got a good start, the arm is moved to the second button, thereby leaving the first section of the resistor out of the circuit and increasing the current in the armature. After the resulting increase in speed,

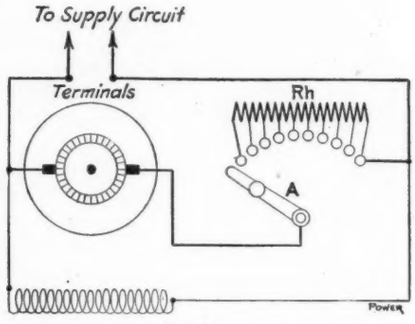


Fig. 115. Shunt-wound Motor and Starting Rheostat

the arm is moved to the third button, and so on, until the last button is reached and all of the resistor is cut out, leaving the armature connected directly to the supply circuit.

Horsepower

Just as a steam engine has a "horsepower constant," by which the mean effective pressure may be multiplied to find the indicated horsepower, so a shunt-wound electric motor has a horsepower constant by which the armature current may be multiplied to ascertain the horsepower.

The horsepower constant may be derived in two ways: either from the impressed electromotive force and armature resistance or from the magnetic flux.

*A resistor is a conductor used solely for adding to the resistance of a circuit.

armature wires and speed. The former is easier. The mechanical power (in watts) developed by the armature is equal to the watts taken from the line minus the watts lost in driving the armature and overcoming the resistance of the armature circuit. The watts lost by armature-circuit resistance cannot be determined without knowing what the armature current is, but as the total armature losses are commonly between 4 and 10 per cent. of the input, an assumption of 6 or 7 per cent. will not be far enough out to cause important error. On this assumption, the horsepower constant is given by the simple formula:

$$\frac{Impressed\ e.m.f.}{800} = hp.\ constant$$

Multiplying this constant by the full-load armature current will give a fair approximation to the full-load brake horsepower of a shunt-wound motor, within the ordinary workshop range of sizes—say from 1 to 50 hp.

The formula is based on the fact that if there were no losses whatever, the horsepower of the armature would be equal to the armature input in watts divided by 746; and on the assumption that the average armature losses are 6¾ per cent. of the armature input. If 93¼ per cent. of the impressed armature watts divided by 746 equals the brake horsepower, then the impressed armature watts divided by 800 will equal the brake horsepower and the impressed electromotive force divided by 800 will equal the brake horsepower *per ampere of armature current.*

Care of Direct Current Switchboards

By G. B. Longstreet

As all the power delivered by the generators has to pass through the switchboard, it necessarily follows that strict attention should be given to the appliances mounted thereon to insure their working properly.

The switchboard should be located in a dry place and well insulated. If there are windows near it, they require careful watching in stormy weather. The board should be kept clean and neat both in front and back, and enough room provided in the rear to allow a person to work freely without coming in contact with any wire or busbar.

If a compressed air blast is to be had this should be used occasionally for blowing the dust from the board, a light blast being used without a metal nozzle attached to the hose. Where this is not obtainable the work can be done with hand blowers.

It is best to put the name of each circuit on a card and place this directly over the switch controlling that circuit. Receptacles made expressly for receiving these cards can be purchased at a small cost, also one or more drawings of the switchboard and connections are a help to the attendant at all times, and on large or complicated boards these are a necessity.

The switch blades should be kept bright to make good contact, and should work freely. A very small amount of vaseline applied occasionally to the blades will allow them to close easily and will not interfere with good contact.

Automatic circuit-breakers require considerable attention. They must work freely and accurately and both the carbon and the copper contacts should be examined frequently, especially after bad blowouts, to make sure that good contact is made and that there are no badly burned or blistered parts. If there are, the parts should be replaced.

Rheostats must also receive a like amount of attention. A good contact must be maintained between the movable finger and buttons or bars, as the case may be. A small amount of vaseline applied to them gives free movement without impairing contact. In the case of bar contacts special care should be taken that the intervening spaces do not fill with dirt.

Voltage regulators should receive attention according to the directions furnished by the makers. All meters should be calibrated at regular intervals and if found incorrect should be corrected. Busbars should be marked "positive" and "negative."

In plants where the service cannot be suspended to make repairs to circuit-breakers or switches, a jumper may be used. This is made of cable with a forked terminal soldered to each end. Before pulling the switch or circuit-breaker one end of the jumper should be fastened to the switch-post of the out-going cable and the other end connected to the switch-post of the out-going cable of the circuit chosen to take care of the load during repairs. Where possible it is preferable to do this when the load is light, but if this is impossible care should be taken to choose a strongly fused circuit upon which to tap. A good policy is to have an extra switch or circuit-breaker to be used for this purpose only.

CORRESPONDENCE

Motor Windings

Where a number of induction motors of different types and makes are in operation, it is convenient to have at hand diagrams indicating the method of connecting the phases, when new coils are to be installed.

After dismantling the machine so that the end connections can be seen, make a pencil drawing to a reasonably large scale in the following way: Draw a circle, and by diametrical lines divide into as many segments as there are coils in the stator. Close to each line and on opposite sides indicate by pencil the inner and outer terminals of the coils. Follow out and indicate on the drawing in different colors one phase at a time. After tracing for a distance of two or three poles, count back to the beginning and check for errors. A little practice will be required to trace these readily. When complete make a diagram on tracing cloth for filing in a loose-leaf notebook, preferably using different colors for the different phases as on the rough drawing, from which a print can readily be made for use on the job.

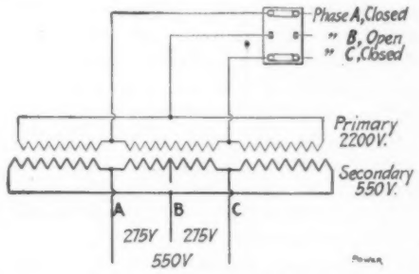
G. B. Cook.

Miami, Fla.

Blown Fuse

In the Nov. 5 issue, Mr. Koppel, in referring to the sketch therein given, wishes to know which of the primary fuses were blown, thereby causing the motor trouble. He states that upon making a voltage test at the motor the following readings were taken; *A* to *B*, 550 volts; *B* to *C*, 275 volts and *A* to *C*, 0 volts.

Phase *A* on the primary was the one that was open, but I wish to call attention to the test which Mr. Koppel made. Owing to the incompleteness of his sketch in which he failed to show the manner of test and the outside wiring on the secondary through starting box, it is hard to tell just why there was no reading between phases *A* and *C*.



Primary Fuse *B* Blown

The accompanying sketch shows the inside connections at the same transformers, delta connected. For simplicity, assume that phase *B* on the primary is open. This does not leave either transformer dead, although the two outside ones will be left in a weakened condition. Each outside transformer will be operating on one-half the line voltage, as one circuit gives two transformers in series. Then the voltages on the secondary side should read in relation to their respective position to the primary; that is, from *A* to *C* there will be full voltage and between *B* and *C* or *A* and *B* there will be one-half the normal voltage.

C. W. Cox.

Alameda, Calif.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Gasoline Engine Economy*

By A. E. Potter

Carbureters differ greatly in their consumption of fuel, and some can be adjusted to operate on materially less gasoline than others. With a motor throttled to its lowest speed the mixture has to be materially richer in gasoline vapor than when run at maximum speed, for two reasons; first, to allow for dilution of the charge by air drawn into the inlet-valve chest past the valve stem, and, second, for the reason that upon opening the throttle, before the engine can pick up speed, the velocity of the air past the needle valve is temporarily slower, drawing in less gasoline and resulting for a short time in a slightly weaker mixture. If this mixture is made very much poorer the motor will not pick up power, often noticeable in a motor car on a hill, and unless the speed lever is dropped back in such cases the motor will be "stalled." If the air velocity is too great, it is likely to result in an accumulation of unvaporized gasoline in the inlet manifold, and upon opening the throttle this raw gasoline is drawn into the cylinders, choking the motor with a gas so rich that it will not ignite, or upon ignition will produce very little power, and as in the former case may "stall" the motor. In one case the mixture is too poor and in the other too rich, both to be avoided if possible, the latter being more important than the former, as it results in waste of gasoline. This latter condition is quite likely to be present in motors equipped with carbureters too large for the motor, always resulting in waste of fuel, no matter whether the mixture be too rich or too poor.

The first internal-combustion engines using gasoline fuel were of the hit-and-miss-governed type.

While no great skill is needed to design a vaporizer or constant-level carbureter that will operate an engine of this type, and that will allow the development of rated horsepower, to design such a device as will result in minimum consumption of fuel per horsepower-hour delivered is not so easy.

The usual design is a straight pipe with a spraying nozzle entering the lower side, a pump to supply gasoline to a cup or bowl with an overflow back to the tank. This pipe may be the same size as the engine intake or may be smaller, but never have I found a device of this kind employing the true venturi principle—a principle that will give the air its maximum velocity to completely vaporize the gasoline without reducing the volume of each charge to such a point as to result in a reduction of power.

This type of engine, if properly designed, has a vaporizing device that will deliver maximum horsepower at a minimum consumption of gasoline, and when called upon for explosive charges intermittently the air has at all times practically the same velocity, and as a result the efficiency should be practically the same at high, low and intermediate speeds.

But with throttle-governed engines, conditions are such that marked fuel economy under varying power requirements is the exception, rather than the rule.

It is only reasonable to believe that the higher the air velocity the more completely will the gasoline be vaporized and the more intimately mixed with the air, resulting in high efficiency. On the other hand, to induce this high velocity the volume of the incoming charge may be reduced to such an extent that any loss as a result of imperfect vaporization may be more than offset by a reduced output. So long as there is a safe margin of power above the greatest requirement, such a condition would result in economical operation, but if extra demands are made of such an engine, it would not be able to deliver any more power than an engine of relatively less piston displacement.

To overcome these and other disadvantages, and to render such engines more efficient at varying speeds, they are usually equipped with automatic carbureting devices. These may be broadly divided into three classes: those with proportional openings for air and gas; those that dilute a rich gas with auxiliary air; and those that adjust the amount of gasoline to an auxiliary supply of air.

When properly proportioned to the demands of the engine, each class should show high efficiency. With engines that are not subjected to sudden and intermittent power demands, carbureters with proportional openings give fair results, but they seem to operate best with a mixture slightly rich in gasoline and are not generally recognized as being especially economical.

In the other two classes if the velocity of the air is too high there is likely to result a loss of volume and a resulting drop in the horsepower delivered, while if too slow there is a strong possibility that the gasoline will not be thoroughly broken up and mixed with the air, with loss of efficiency, and the result is poor economy.

A series of tests of six different carbureters, conducted at Purdue University, and reported by Prof. George W. Munro in a paper read last June before the American Society of Mechanical Engineers, shows marked differences in fuel consumption and power developed.

While these tests were recorded at 300, 400, 500, 600, 700, 800, 900, 1000, 1100 and 1200 r.p.m., for present purposes the results at 600, 800, 1000 and 1200 only will be compared. At 600 r.p.m., the maximum horsepower developed was 19.53, the carbureter showing an efficiency of 17.4 per cent., this being the highest efficiency shown by any carbureter at that speed, while the minimum horsepower recorded was 14.89, with but 14.3 per cent. efficiency. The efficiency was based on an assumed fuel heat value of 20,700 B.t.u. per pound, which value is assumed in all the following comparisons.

At 8000 r.p.m. the carburetor showing also the greatest power at 600, delivered 25.01 hp., the same power with an efficiency of 15 per cent. that another showed with an efficiency of but 14.4 per cent.

At 1000 r.p.m. the efficiency of this last carbureter increased to 14.5 per cent., delivering the same horsepower as two others showing respectively 19.5 and 20.5 per cent. efficiency, while the carbureter showing the greatest horsepower at 600 and 800 showed 30.441 hp. with an efficiency of 17.5 per cent. Another showed the same horsepower at an efficiency of 19.3 per cent.

It was at 1200 r.p.m., about the speed at which the engine should have shown best results, that the greatest disparities were apparent, three different carbureters showing the same horsepower delivered, while their efficiencies proved to be respectively 15.5, 22.2 and 15.3 per cent., the consumption of gasoline being proportional to these different percentages, the best economy being 0.74 pint per horsepower-hour, and the most uneconomical nearly 1.07 pint per horsepower per hour.

The plausible theory to account for these varied results, is that the gasoline was less perfectly vaporized and mixed in one instance than in either of the other two.

*From a paper read before the National Gas Engine Association at Indianapolis, Dec. 5, 1912.

There is one other patent cause of waste of gasoline which deserves brief mention; this is the timing. To ignite a charge any later than will give maximum power means waste of fuel. The earlier the ignition can be set without knocking, the nearer closed can be the throttle; also the more synchronous the timing the earlier it can be set. A single spark occurring with absolute regularity, not early and late intermittently, as may occur in a single-cylinder engine with parts badly worn or with loose timing apparatus, will develop more power than a series of sparks which may or may not be timed to begin at absolutely the same instant every time when called upon to furnish ignition. In like manner a timer that does not have all its contacts spaced absolutely correct may cause the ignition to occur early in one cylinder, while one or all the others may get the spark materially later.

Gasoline-engine economy, therefore, seems to resolve into four factors:

1. The proper proportioning of the carbureter to the engine; that is, neither too large nor too small.
2. Proper carbureter adjustment.
3. The elimination of all carbureting devices that waste fuel.
4. Synchronous and as early timing as is consistent with intelligent operation.

The Junkers Engine—VI

By F. E. Junge

Balancing

First consider the inertia forces and tilting moments of a combination of three Junkers tandem engines with cranks set at 120 deg. The residual inertia forces, which were considered under the heading "Pressure on Bearings of Junkers Engine," (see Nov. 26 issue) for each engine plane taken as a whole, completely neutralize each other. This will be made clear by the following illustrations, of which Fig. 31 shows the constructive arrangement of the unit and Fig. 32 the pressure exercised by inertia. In spite of this neutralization a tilting moment exists, the nature of which is shown in Fig. 33. For the ratio of crank circle radius to length of connecting rod of 1 to 5, the maximum unbalanced inertia force for each tandem engine is two-fifths of the inertia force for a single engine at the dead center with an infinite connecting rod. These forces must be transmitted through the engine's bedplate, without perceptibly straining the latter, if an effective balance of the inertia forces is to be attained. Considering the small value of these forces in the Junkers engine, and their rapid rate of change, these conditions may easily be satisfied by a light bedplate. The maximum value of the tilting moment, is approximately 1.73 times the residual inertia force at dead center with an infinite connecting rod, multiplied by the distance between two successive center lines of the engine.

This couple tends to rock the engine on its foundation, as was shown for the reaction of the twisting moment (see page 715, Nov. 12 issue). However, since this moment is small in magnitude and is subjected to rapid changes, it may easily be met.

The inertia forces and tilfing moments of a three-cylinder Diesel engine with cranks set at 120 deg. will next be considered. In this arrangement which is represented in Figs. 34 to 36, the inertia forces entirely neutralize each other, as in the Junkers engine. But, since the inertia forces occurring at dead center in the Diesel engine are three times as large as those existing in a Junkers engine under the same conditions, the unbalanced tilting moments in the former are decidedly larger than in the latter. Moreover, the changes take place only one-half as fast as in the Junkers engine. Therefore, to procure satisfactory inertia balance in the Diesel engine, it is necessary to design the engine frame for forces which are three times as large as those of the Junkers engine. Hence a heavy, expensive frame and substructure are necessary.

Now consider the six-line arrangement in Junkers engines. The tilting moment of the three-line arrangement of cylinders can only be completely neutralized by applying to the same bedplate an opposing moment, which, for all positions of any crank, will be in equilibrium with the couple in question. This is attained by the arrangement of a second similar engine on the same bedplate. In the Junkers three-line tandem arrangement the tilting moment runs through the same values every half revolution (see Figs. 31 to 33). As far as abolishing any free tilting moment is concerned, it is thus immaterial as to whether the compensating three-line tandem set be fixed at 0 deg. with respect to the crank of reference of the first engine, or at 180 deg. Since the setting of the cranks at 180 deg. produces a uniform twisting moment, the division of the crank-pin circle into six equal parts should be followed. The couple exercised by the one engine on the other, through the medium of the frame, is, as already mentioned, 1.73 times the unbalanced inertia force at dead center for an infinite connecting rod, times the distance between the center lines of two adjacent cylinders. Considering the rapid alternations of this couple and its small magnitude, a complete inertia balance may be obtained, in the Junkers engine, by providing a light connecting bedplate. To this is added the advantage of completely utilizing the six cranks to procure a uniformly combined crank effort or twisting moment.

The six-line tandem arrangement of the Junkers engine thus provides a perfect inertia balance and a highly uniform turning moment, notwithstanding that the engine and substructures are light and inexpensive.

Considering the six-cylinder arrange-

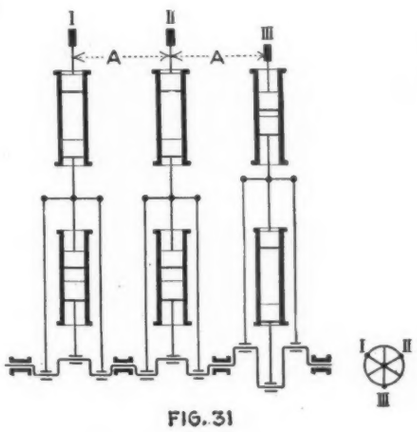
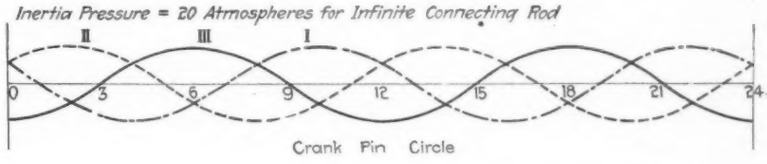
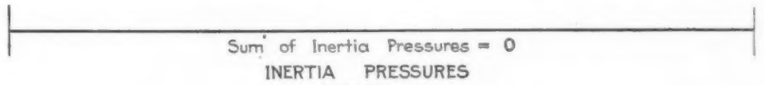
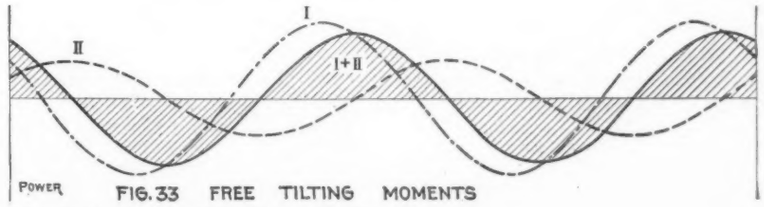


FIG. 31





INERTIA PRESSURES
FIG. 32



POWER FIG. 33 FREE TILTING MOMENTS

Graphical Representation of Forces in Junkers Engine

ment in Diesel engines, should a balancing of the tilting moments be desired, this can be accomplished by placing two three-line units in juxtaposition, at 0 deg. relative displacement of the cranks. This restriction is essential because the unbalanced couple goes through one complete cycle per revolution. Moreover, the bedplate is subjected to a tilting moment 150 per cent. larger than that occurring in the Junkers engine, and the alternations are one-half as slow. Therefore, a satisfactory inertia balance in the Diesel engine can be attained only by a heavy, expensive bedplate. In consequence of the 0-deg. spacing, the twisting moment is only one-half as uniform as in the Junkers engine.

Therefore, to procure complete balance in the Diesel engine the frame must be so proportioned as to transmit forces and moments 200 per cent. and 150 per cent. larger, respectively, than those encountered in the Junkers engine, with alternations one-half as rapid. Yet, the six-

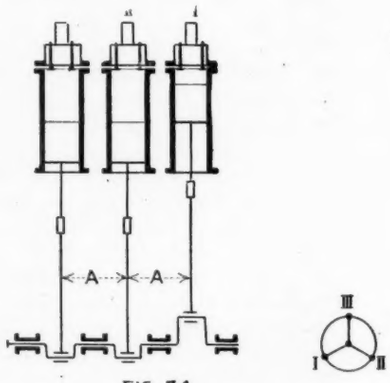


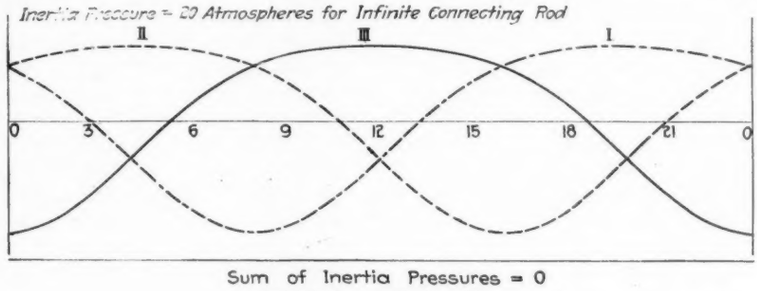
FIG. 34

cylinder arrangement does not provide a more favorable turning moment than an ordinary three-cylinder engine. Notwithstanding the additional expenditure, the twisting moment is only half as uniform as that peculiar to the Junkers aggregate. The result is a heavy expensive frame and substructure. If in the six-line Diesel arrangement a turning moment equivalent to that in the Junkers engine is to be attained, it can be done only by sacrificing the tilting moment compensation provided in the frame. A free unbalanced couple 300 per cent. larger than that in the Junkers three-tandem arrangement thus results.

Frame and Supports

From the foregoing considerations the following deductions apply to the bedplate and foundation: Owing to the excellent inertia balance in the Junkers engine its demands as to substructure are but small; hence the foundations may be light and inexpensive. Moreover, harmful vibrations in the building, vehicle or vessel are thus obviated. In all cases where perfect balancing and quiet running is required the Junkers engine is superior to all other reciprocating combustion engines. Consequent to the interlocking of the acting forces in the power transmitting mechanism itself, the cylinders and their connections with the main bearings are not subjected to any reacting stresses. In the normal horizontal Diesel engine the excessive reacting forces have to be taken up by the cylinder and the bedplate. The connection between the cylinder and the bedplate is thus strongly subjected to bending and, therefore, must be made as inflexible and as heavy as possible. Cast iron, however, is never to be relied upon in transmitting large forces. Hence this arrangement is always the weak point in the design of horizontal Diesel engines.

As to the main bearings in the normal Diesel engine they have to support extremely large loads, owing to the large piston forces exerted. Thus, to keep within the bounds of an acceptable specific pressure the bearings must be heavy and long, calling for careful superintendence. The contrary holds true in the Junkers engine. Here, owing to the compensating arrangements, the main bearings are well relieved from their loads, so that with relatively short bearing surfaces only low specific pressures are to be anticipated.



INERTIA PRESSURES
FIG. 35

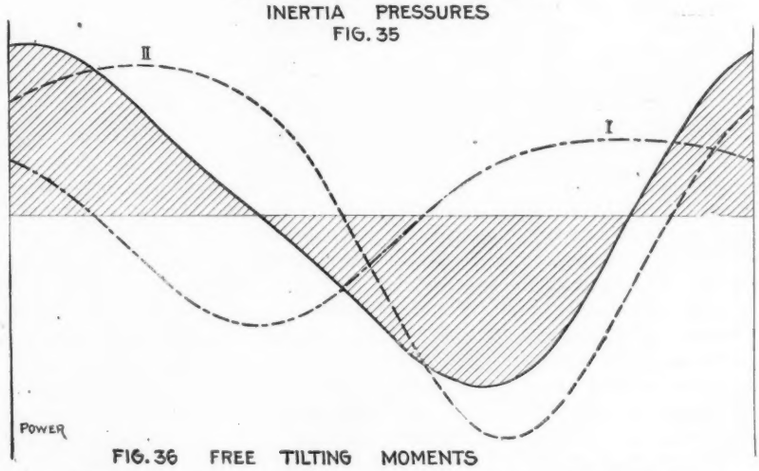


FIG. 36 FREE TILTING MOMENTS

Graphical Representation of Forces in Diesel Engines

On the other hand, if the electrodes are making contact there will be no spark unless the contact points are dirty or badly burnt.

The correct way is to try the screwdriver method by first holding the igniter in contact, and then holding the electrodes apart. If there is no spark in the first place at the screwdriver and there is a good spark when the electrodes are held separated, then the igniter and wiring are all right.

Hawley L. Scott.

Bangs, Ohio.

CORRESPONDENCE

Operating Gas Engines

Mr. Brennan's article on operating gas engines in the Nov. 26 issue states, in the list of troubles common to the make-and-break system of ignition: "To ascertain at once if the existing trouble is in the wiring or the igniter, place the switch in position to close the circuit and then with a screwdriver form a circuit from the stationary electrode on the igniter to the cylinder. If a good spark results by moving the screwdriver, the circuit is complete and the trouble is in the igniter. Having traced the trouble to the igniter, it may be due to dirty points or to the actuating springs working improperly. On the other hand, if no spark is had it will be necessary to look over the battery connections and terminal points of all the wiring."

While the foregoing is true in a way, yet if the electrodes are not in contact there will be a spark at the screwdriver.

The second annual electrical show of the Peoria Show Association will be held in the Coliseum. Peoria, Ill., Jan. 18 to 25.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Repairs and Improvements in an Ice Plant

By W. S. Luckenbach

As the ice-making season is over, every owner and conscientious engineer should seriously consider ways and means of increasing the capacity of his plant without materially increasing the operating expenses or fixed charges. All changes or additions require careful consideration, but it will be a comparatively easy matter if the engineer has kept daily records covering the entire plant, viz., consumption of fuel, temperature of feed and cooling water, temperature of distilled or raw water for ice making, brine and liquid anhydrous temperatures, and in an absorption system the temperature of the poor liquor at the absorber. If he has also noted the cost of labor, oil, packing, etc., and the amount of ice produced, he is well equipped to sum up the situation. It will be a great help if he can compare his plant with others working under similar conditions.

The engineer in charge should make a note of all defects, large or small, from the boiler room to the dump tub and leave nothing to memory, as the failure to replace even a nipple or a fitting may cause trouble and expense during the busy season.

Have the steam boiler thoroughly gone over from grate bars to safety valve. In the writer's opinion one of the principal adjuncts is a first-class heater and purifier. This apparatus will remove a large percentage of the impurities and indirectly will increase the efficiency of the boiler by reason of cleaner tubes and less blowing down to remove the sludge. Every extra gallon of hot water blown into the sewer adds to the cost of fuel. It is good practice to insert a thermometer in the feed line so that the temperature of the water from the heater may always be known. The rear-end soot blower is also a fuel-saving device. In the old method of blowing from the front, the flue doors must be kept open; and when the tubes are over 12 or 14 ft. long it is impossible to thoroughly clean the back ends on account of blowing against the draft and into an inclosed chamber. When blowing from the rear the work can be done at any time and the tubes cleaned thoroughly, because the soot is blown with the draft and up the stack instead of into the combustion chamber, from which some may return a second time into the tubes.

Boiler-feed and cooling-water pumps need careful attention especially if steam driven. The examination of pistons and slide valves must be made under steam pressure. Disconnect the valve stems from the rocker-arms and with the back head off test the valves in various positions, as they may be tight when covering the ports and leak at one end when taking steam at the other. The water ends also require attention. If the cylinders do not fill at each stroke the pump must be run at higher speed; otherwise more steam will be required to pump the same quantity of water. For the same reason the ammonia pump should be put in first-class condition.

Every season the generator coils or pipes should be cleaned because the impurities of the aqua ammonia frequently adhere to their surface and form a nonconductor of heat. Especially is this necessary when exhaust steam is used for generating the gas from the rich liquor. With dirty coils the volume of exhaust must be increased or a higher pressure (meaning also a higher temperature) maintained. All coils or pipes should be tested to 500 lb. and on the high-pressure side especially it is common to use extra-heavy pipe.

Atmospheric condensers are generally located on the roof, and if so, should be protected from the sun's rays. The protection in the shape of a roof has a twofold effect in that it shades the coils and creates some draft at all times; hence less cooling water, less pumpage and less steam required. Double-tube condensers are usually installed in the building, but should be so located as to have a current of air passing over and through them, for the same reasons as above. It is important to have the liquified gas pipe from the condenser to the expansion valve run through a cool part of the building in order to prevent an increase of temperature.

If the freezing tank and coils have not been cleaned for several seasons, they should receive attention. To prevent corrosion this work should be done quickly so the expansion coils will not be exposed to the atmosphere any longer than actually necessary. Each coil should be blown out separately and tested to not less than 300 lb. See that the pipes in every round of coil are straight, thus avoiding the possibility of a trap which would seriously decrease its efficiency.

If it has been difficult to maintain a comparatively even temperature it may be necessary to resort to brine circulation. Either of the two methods outlined below may be used. Set a brine pump close to the freezing tank where it will be protected from excessive heat. The suction pipe should run along the bottom of the tank three-quarters of the way across the bath, with the perforations in the pipe turned upward. The discharge pipe at the other end of the tank should also be perforated and be several inches below the surface, with the holes turned down, and the pipe leading from the suction to the discharge should be inside the tank if possible or at least be protected from the surrounding atmosphere. The pump should have sufficient capacity to change the liquid about once every six hours. There is, however, no hard and fast rule to go by. The brine is simply changed enough to insure a uniform temperature of the proper degree throughout the bath. Any additional circulation means a loss in steam.

The other method is to partition the tank longitudinally into two distinct divisions, leaving ample space opposite the agitator for the brine to flow from one division to the other. The agitator consists of, say, a 16-in. pipe about 4 ft. long fitted with a four-bladed propeller, the whole set at an angle and so arranged that the brine will be drawn from the bottom of one division and discharged upward into the other division. The methods of driving the propeller are many, but in this case two-to-one bevel gears were used and driven with a ¾-in. rope from a sheave attached to the ammonia-pump flywheel. The propeller shaft runs in a babbitt metal step box, secured to a cross bar fastened to the 16-in. pipe, for an entire season without attention, the exposed bearings, of course, needing lubrication. For a 30-ton machine the speed would be about 40 r.p.m. and the power required practically nil.

Use nothing but new pipe and fittings on the ammonia system because the threads will then be sharp. Do not use any pasty lubricant to make up joints such as red lead, glycerin, litharge, etc., because particles will lodge between the threads, making it impossible to screw the fittings iron to iron. These particles will harden and be tight but it will be only a question of time before the ammonia will penetrate and cause a leak, and most likely this leak will occur when you can ill afford to remove it. The writer's experience has been to first secure pipe

and nipples which have sharp threads and no internal, ragged edges, use a little graphite and good oil and screw up good and hard iron to iron. A lasting job and a joint that can be readily unscrewed will be the result.

Freezing Can Ice in Twelve Hours*

By W. Everett Parsons

Ordinarily the time for freezing a 300-lb. block of ice in a standard can varies from 42 to 60 hr., depending on the temperature of the water filled into the can, temperature of the brine, rapidity of the brine circulation, etc. These conditions remaining constant, the freezing time is about proportionate to the square of the thickness frozen. Advantage of this is taken in the quick-freezing process owned by the United Ice Improvement Co., of New York City. The accompanying diagrams show that an ordinary standard 300-lb. can may be used. Three-inch pipes, sealed at their top ends, project upward from the bottom of the can. The lower ends of these pipes are open and are screwed into a plate fastened to the under side of the can so that a tight joint can be made and the brine used for cooling cannot leak into the can. Under the can is a brine-circulating header with three small pipes for each can projecting upward, and so arranged and spaced that when the can is in place for freezing the small pipes extend upward inside of the 1-in. pipes. The cold brine is circulated through the header and passes up through the small pipes, then down again inside the 1-in. pipes to the bottom of the can and up the sides of the can to the top. Instead of the arrangement shown in Fig. 1, the small pipes can be attached to the can when it has to be lifted from the tank in the usual way. Fig. 2 shows a cross-section of a 300-lb. block of ice frozen in 12 hr. by the new process, with brine entering the pipes in the can at about 12 deg. F.

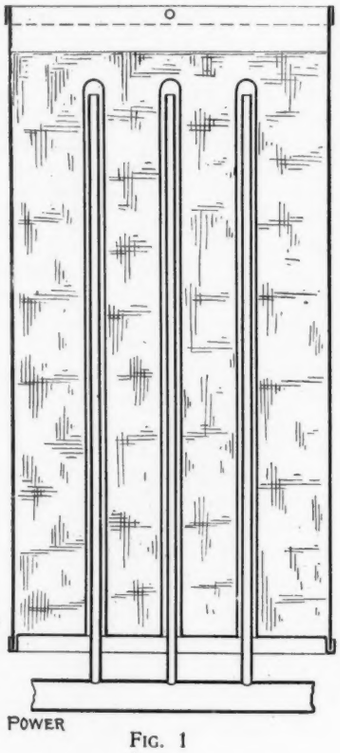


Fig. 1

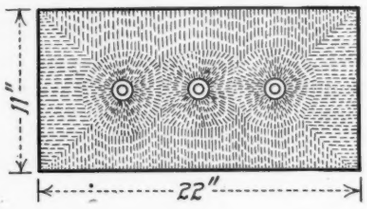


Fig. 2

The proportion of this cross-section of ice frozen from the sides of the can is about 63.6 per cent., and from the three pipes about 36.4 per cent.; whereas the periphery of the sides is 66 in. and of the three pipes 12.4 in. In other words, the ratio of the ice frozen from the pipe surface to that from the outside surface of the can is 1 to 1¾, while the ratio of the surface of the three pipes to that of the sides of the can is 1 to 5¼, showing that 5¼ times as much surface in the outside of the can freezes only 1¾ times as much ice. The rapid flow of the brine in the pipes and the slightly lower temperature of the brine account for the better showing made by the pipes. When the block of ice is released from the can there are three holes about 1 5/16 in. diameter, which extend from the bottom to within 3 in. of the top. When the block is stood upright in the ice storehouse, the holes are sealed by the floor and there is no melting in the holes. If the ice storage is kept below the freezing point, and it is desired to eliminate the holes, they may be filled with cold water, which will freeze solid without any further attention.

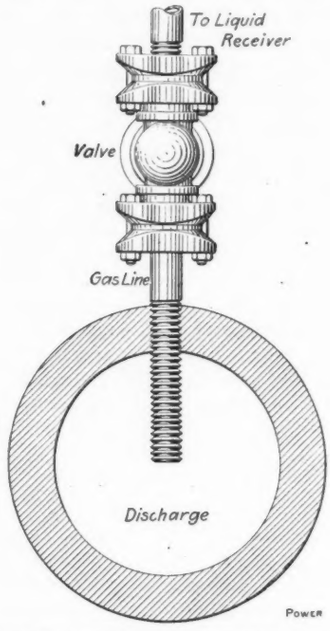
*Abstract of paper read before the Eastern Ice Association, New York City.

CORRESPONDENCE

Gas Relief from Liquid Receiver

From observation and experience I have noticed that little attention has been, or is being, paid by refrigerating engineers to gas relief from the liquid receiver. Most gas-relief pipes are tapped into the bottom or sides of the gas-discharge line at or near the header on the condenser. This arrangement does not properly relieve the gas generated in the receiver, and as a consequence it passes out with the liquid to the expansion valves, causing them to sputter and retard the steady flow of liquid ammonia.

To remedy this trouble I trapped the gas-relief line into the top and through to the center of the discharge line at the condenser gas header in the manner shown in the sketch. I made a ½-in. nipple with a running thread long enough to go down to about the center of the discharge line so that the flow of gas



Gas Drawn Into Discharge Pipe

in this line rushing past the opening in the nipple on its way to the condenser would draw the gas out of the relief line from the receiver instead of allowing it to back down to the receiver as it generally does where the line is tapped into the side or bottom of the discharge line and merely enters the wall of the pipe.

From the above changes, I have obtained excellent results and was well repaid for the extra work of changing the piping.

C. E. Anderson.

Chicago, Ill.

A French metallurgist has manufactured an alloy, with the hardness of steel and with great tensile strength. by the addition to copper of chromium, aluminum, nickel and zinc at certain temperatures, which are maintained for specified lengths of time.

An interesting pamphlet has been published by the Illuminating Engineering Society under the title of "Light: Its Use and Misuse." The illustrations are well chosen and present concrete ideas on this important subject. Copies can be obtained from the secretary of the society, at 29 West Thirty-ninth St., New York City.

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POWER

Increased Plant Efficiency

That further gains in the economy of the power plant will be brought about in the boiler room rather than in the engine equipment or auxiliaries has been repeatedly stated in recent years. This is undoubtedly true, although refinement of operation and improvements in steam-using apparatus will continue to be made from time to time.

Since the first steam engine, the aim of the inventor and manufacturer has been to increase its economy and to reduce the cost of operation and upkeep. This apparently has been carried about as far as it is possible to go, insofar as generating units and their auxiliaries are concerned.

It is interesting to glance back over the changes that have been made in power-plant apparatus. The old slide-valve engine was replaced by the Corliss, both simple and compound. This was the first great step in cutting down the steam consumption. Other designs of four-valve engines have followed with equally satisfactory results.

Condensers have added greatly to the economy of steam engines and are the dominating factor in the successful and economical turbine operation. When used with reciprocating units the steam consumption is reduced from ten to fifteen pounds of steam per horsepower-hour.

Coupling the reciprocating engine exhaust to a low-pressure turbine has further reduced the steam consumption per kilowatt-hour. This represents the most economical operation of power-plant generating units.

But what of the boiler room, and where is the economy to be obtained in this section of the power plant? Boilers today are as well made as high-steam pressures demand, but this does not add materially to the economy of the boiler plant.

Evidently the furnace design and the method of burning the fuel are the two avenues through which engineers may expect to increase plant economy. The furnace is a problem in itself. It can be built without any forethought as to whether it and the grates used are suitable for the kind of coal to be consumed or not. Or it can be designed with the aim of obtaining the highest rate of combustion of the fuel before the gases strike the cooling surface of the boiler. The dutch-oven, if properly designed, has this advantage. It has, however, the disadvantage of occupying additional floor space over the ordinary furnace.

Combustion of the fuel is, to a great extent, under the control of the fireman. If he knows what results are desirable, and will work to that end, fairly economical operation will obtain. If he does not understand combustion nor know what is required to secure the best furnace performance, indifferent results may be expected.

Increased boiler-plant economy is dependent upon a properly designed furnace, and skillful handling of the fires. Suitable apparatus to enable the fireman to determine when his boilers are or are not efficient is obviously needful. These comprise CO_2 instruments, water weighers, accurate coal scales and such registering instruments as will enable a check being kept upon the everyday performance of the plant.

Boiler Inspection and Engineers' License Laws

The time is at hand when the legislative mills of the several states will commence their annual or biennial grind, and committees from engineers' associations will sit up nights and wrestle with unfamiliar legal phraseology in attempts to evolve license and inspection bills, which will find favor in the eyes of the law makers. The bills will be introduced and referred to committees; the associations will tax themselves to send representatives to hearings. They will present better reasons for such laws than can be presented for seventy-five per cent. of those which pass, and then the legislature will adjourn and the com-

mittee will try to explain to its parent body why it failed.

The reason for most of the failures which mark the struggles of more than a quarter of a century for such legislation is the power of the representative of the interests. The average user of boilers and the employer of engineers looks upon government inspection as an unwarranted interference in his business, and upon a proposition to examine and license engineers, as a conspiracy to make practical engineering a close corporation and artificially restrict the supply of labor in that field. As a result of this conviction and of their influence in the legislatures the United States occupies the proud distinction of killing by boiler "accidents" more people and destroying more property than any other country in the world in proportion to the number of boilers in use.

There should be no question of the duty, to say nothing of the right, of the state to protect its citizens against dangerous boilers or boilers in the charge of incompetent men. Such a provision is not a restriction of personal liberty, or industrial activity, but an assertion of the people, the men and women who walk over and work within range of these magazines of energy, of their right to protection from their abuse.

The adoption and enforcement of such laws in Massachusetts and Ohio has weeded out many cases of incipient explosions and put responsibility where it belongs without working any hardship to the employer who wants things straight and right; and a canvass of the steam-plant owners in those two states would disclose that the law has brought none of the dreaded consequences and has won their favor.

It is very desirable that, as this legislation is effected in other states, as it undoubtedly will be, the laws should be substantially uniform. This is especially true in the requirements as to boiler construction. The Massachusetts and Ohio laws provide for boards of boiler rules. These boards prescribe the boiler which may be run in their respective states, and if similar boards were appointed in many of the states and their specifications were widely different, a hardship would be imposed upon boiler manufacturers and upon engineers who need to be informed upon the requirements of all the states.

To committees appointed to procure the passage of such laws we commend that already in force in the two states mentioned. Unimportant modifications would adapt it to the constitution and the requirements of any state; and if the boards of boiler rules appointed under such laws adopt the rules, which are the results of experience in the states which have practiced them, there will be established a condition of uniformity devoutly to be wished. Meetings of representatives of the boards of the several states with regard to extensions and revisions of the rules would lead to the preservation of unanimity and the bringing to bear upon the question the united engineering talent of the country. The committee on Standard Boiler Specifications of the American Society of Mechanical Engineers may evolve a specification which will be so universally satisfactory that it can be adopted by all, and a boiler built to it will be acceptable in any state in the Union.

"Direct" or "Continuous" Current

At present there is a lively discussion in electrical circles as to the advisability of substituting the term "continuous" for "direct" current. In its strictest sense, direct current implies a current of unidirection in contrast to an alternating current in which the direction is continually reversed, whereas continuous current is not only in one direction, but is non-pulsating. This, of course, could not be applied to a current obtained through a mercury rectifier, which, although direct, is pulsating in character. Thus it is apparent that "direct" is the broader term and can be applied without error to either case whereas it would be incorrect to call a rectified current "continuous."

Several electrical papers and societies have recently gathered the opinions of leading electrical engineers relative to the question. These show that while the term "continuous" does not lack supporters, the majority seem to prefer "direct" current. Moreover, this view has the backing of the Standardization Code of the American Institute of Electrical Engineers, which states that "a direct current is *any* unidirectional current."

The English language as compared with several foreign languages is deficient in technical terminology, and steps to remedy this would receive the approval of most engineers. However, any attempt along these lines which would tend to confuse rather than to clarify the meaning should be discountenanced. The term "direct" current has been sanctioned by long use and it is not incorrect. The only argument that can be put forth against it is that it is not specific enough. However, as rectified current forms only a very small part of the total direct current in use, when a definite designation is required, the terms "rectified" or "pulsating" may be employed.

Decreased Enrollment in Technical Schools

Statistics show that for the past two years the technical schools throughout the country, in general, have reached their maximum in the number of students enrolled and in a few cases are even showing a slight falling off.

At first glance this might seem to indicate that the demand for technical graduates is decreasing. This assumption has proven erroneous, however, by the records of the employment bureaus in the schools affected, which show that the demand greatly exceeds the supply. A significant fact in this connection is that the greatest demand comes from the large companies.

Looking further for the true cause of this condition, we find it to be due largely to two facts—a higher standard of entrance, and the stimulus which the agricultural courses have received lately. The enrollment in the latter is now increasing by leaps and bounds just as that in the engineering courses did a few years back. This may be attributed largely to the agricultural schools being, for the most part, recipients of state aid and having less exacting entrance requirements.

The temporary halt in the number of students in the engineering courses is not to be deplored, however, for the smaller classes can be handled more satisfactorily and given closer personal attention, improving the quality of the product of the engineering schools. Moreover, from a purely economic point of view, the greater the ratio of demand to supply the more the technical graduate will command.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Engine Carries Load after Repair to Shaft Governor

The following case illustrates the value of persistency in overcoming power-plant troubles. Early last fall I was employed as assistant engineer in a refrigeration plant to help out during the fall rush.

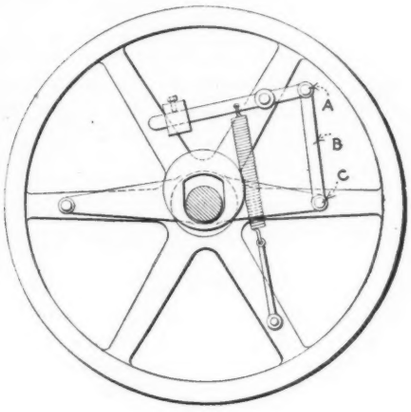


FIG. 1

FIG. 2

SHAFT GOVERNOR AND FAULTY LINKS THAT CAUSED POOR ENGINE REGULATION

This plant was large and lighted by current supplied by a central station, while a good generating outfit stood idle in the engine room.

The reason for not using the set was that the engineers found it impossible to obtain satisfactory regulation of the engine. In justice to them, I must say it was the worst engine in this respect that I ever handled. It would cause a fluctuation of voltage so great as to nearly put the lights out, while the next instant it seemed as though the lamps would burn out from brilliancy.

The chief had worked on it this day with no good results, so I requested permission to overhaul it, which was granted. Referring to Fig. 1, I first removed the nut from the pin *A*, but the pin was rusted in so tightly that it required several hard blows with a heavy copper hammer to force it out. After disconnecting the link *B* at *A*, the pin *C* was removed with difficulty.

The trouble lay in this link, which was so much out of shape as to bind the governor, preventing its proper operation until the terrific speed caused it to let go suddenly.

Fig. 2 shows the link before and after being straightened. As shown, more offset was given to the ends which, after the governor was reassembled, allowed of good regulation. When the chief returned, the central-station switch was open, the engine carrying the load. He smiled and rewarded me by increasing my wages; then I smiled.

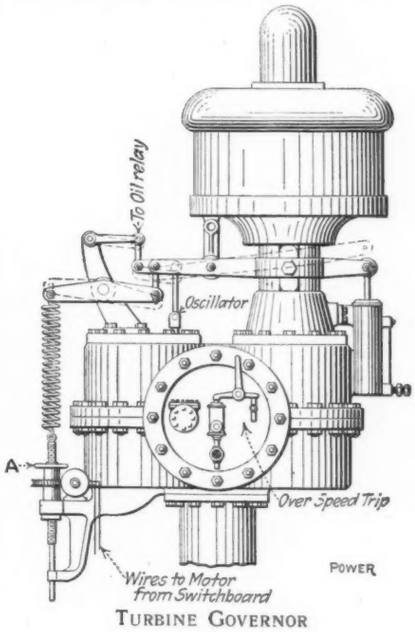
O. L. SHERMAN.

Duluth, Minn.

Why Lightly Loaded Turbine Raced

Our plant is a central-station turbine installation. We had orders from the head office one morning to synchronize with another station 20 miles distant, and to run together until further notice; a 33,000-volt line connected the two stations.

In order to steal some of the load, so as to make a good showing, the chief screwed up on the governor spring adjusting wheel *A* which is used for synchronizing, and raised the speed from 1500 to 1540 r.p.m. Our load is very light from midnight to about 6 a.m., as the other station is cut out about 11:30 p.m. Sometimes the turbine runs along at night for an hour with hardly any load.



TURBINE GOVERNOR

Recently the night engineer reported in the log book that the governor was hunting and varied the speed from 1520 to 1600 r.p.m., so the chief watched the turbine the following day, but could not see anything wrong with the speed or governing, and if it did speed up a little he recorded it as being due to the other station motoring our machine, and did not take any notice of the night engineer's statement. This condition prevailed for a week, until the engineers changed shifts.

The engineer that went on duty at midnight was surprised at the way the governor hunted, because the turbine ran steady in the daytime. The inlet pressure varied from 24 in. vacuum to 100 lb. After studying conditions for a while he lowered the speed to 1500 r.p.m., and the governor ran very steady on the light load.

The illustration shows the governor levers. An oscillating motion is given to the primary and secondary valves, to keep them from sticking, and does not interfere with the speed of the machine. When the sketch was shown and explained to the chief he could not but be convinced that the turbine raced when carrying light loads, and he gave orders to keep the speed at 1500 r.p.m. The trouble was this: At light loads the turbine had to speed up in order to have the governor elongate the already strained spring, as shown by the dotted lines, and this caused the governor to hunt. As the governor came down the spring was less effective, which accounted for the governor running steady while the turbine was loaded.

THOMAS SHEEHAN.

North Adams, Mass.

Wrecked a Coal Hoisting Engine

At a power plant, situated at tidewater, coal is received in barges and hoisted with a steam engine placed about 200 ft. from the boiler house. During recent cold days the steam pipe and cylinder drips froze, owing to the drip valves being left closed. The main steam pipe is shut off in the boiler house and it has a good pitch toward the engine. It is the custom to open the drip on the steam pipe, also the throttle valve and cylinder drips.

As freezing weather had not arrived when the last load of coal was unloaded, these drips were neglected and the condensation from the steam left in the pipe went to the lowest point and froze, but not enough to burst the cylinder or do other harm.

To avoid further trouble, the chief engineer decided to personally look after the opening of the drips. When the hoisting crew went away after finishing the last hoist the chief found the pipe drip open, and, to be sure that no condensation would gather in the pipe, he opened the throttle valve and the cylinder drips. The next morning a new cargo of coal arrived and the hoisting engineer, not knowing what the chief had done, opened the stop valve at the boiler house. When he got back to the hoisting house he found the vertical engine was over on its side, the main bearing caps were off and the shaft was out on the floor; the connecting-rod was broken and the cylinder head was cracked. In fact, the engine was a wreck.

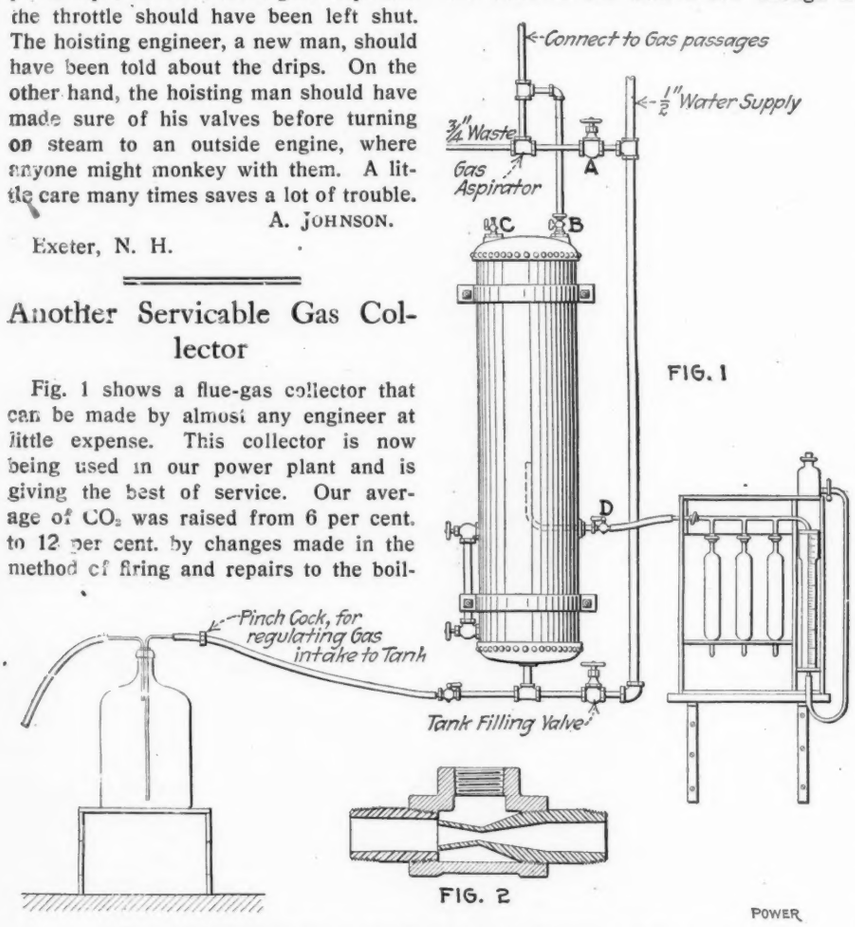
The chief was most to blame, for the main steam-pipe drip should have been piped separate from the engine drips and the throttle should have been left shut. The hoisting engineer, a new man, should have been told about the drips. On the other hand, the hoisting man should have made sure of his valves before turning on steam to an outside engine, where anyone might monkey with them. A little care many times saves a lot of trouble.

A. JOHNSON.

Exeter, N. H.

Another Servicable Gas Collector

Fig. 1 shows a flue-gas collector that can be made by almost any engineer at little expense. This collector is now being used in our power plant and is giving the best of service. Our average of CO_2 was raised from 6 per cent. to 12 per cent. by changes made in the method of firing and repairs to the boilers suggested by using the collector and Orsat. Mechanical stokers are used here.



SHOWING CONNECTIONS FOR PERMANENT FLUE-GAS COLLECTOR

The tank is a 52-gal. house boiler. The aspirator, Fig. 2, is made chiefly from a ½-in. standard tee, and a small brass nozzle. The pipe in the uptake is of ¾ in. diameter, perforated its full length with ⅛-in. holes. To this is attached the pipe leading to the aspirator, which is ⅜ in. The water-supply pipe is of ½ in. diameter.

Before filling the tank with water it is necessary to place therein about 1 gal. of machine oil, which forms a seal and prevents the water from absorbing any of the elements of the sample. Next the valves *A*, *B*, *D* and *E* are closed and the air vent *C* and filling valve are opened. When the oil purges from the vent *C*, the latter and the tank-filling valve are closed. Then *A* is opened and the water allowed to run through the aspirator, a section of which is shown in Fig. 2. When it is certain that gas is being drawn from the uptake, the valves *E* and *B* are opened, and the flow of water from the tank is regulated until the flow is correct to leave the tank empty in the desired time.

We allow 4 hr. as the time for taking a sample. The gas from the flues will take the place of the water and when the water in the tank is low enough it can be seen in the gage-glass, and the valves *B* and *E* should then be closed. The pipe in the center of the tank to which the valve *D* is connected has a hole in it whereby the water can drain out so that it will not run into the Orsat apparatus.

By carefully filling the tank the oil seal can be made to last indefinitely.

ROBERT H. SCHAFER.

Trenton, N. J.

Condenser Problem for Discussion

An old cotton mill well known to me derived its motive power from a beam engine equipped with a jet condenser. The top of the condenser was 17 ft. above the pool from which the condensing water was drawn. This pool also served as a hotwell. The water was usually very hot as much of it was circulated in the pool, which was really the dead end of a canal.

The injection water entered the condenser by virtue of the vacuum in that vessel. The water constantly flowed into the condenser and was as steadily lifted out by the air pump and delivered again at a point 17 ft. above the canal, into which it descended by a pipe and entered the canal horizontally with such force as to show a strong current almost entirely across the canal. So strong was the current that it often led to discussion as to the advisability of placing a small water turbine at the outlet of this air-pump discharge pipe to use this 17-ft. fall.

Now what bothers me at present is where the energy to lift that water into the condenser came from. Was the work done in any way by the engine, or was it a work product of the steam that did not cause more fuel consumption than if the water had been drawn into the condenser from a tank only a foot below the intake? In both cases the air pump would do equal work, just lifting the water from the condenser base and putting it outside.

But the 17-ft. lift was done somehow. Of course, the real acting agent was the external atmospheric pressure which forced the water into the injection pipe; but it could not have done this if the atmospheric pressure had not been removed from the condenser.

Can it be shown that the effect of the vacuum in reducing the back pressure on the engine piston was any the less because the water flowed into the condenser by virtue of the vacuum within it and was not pumped in or allowed to run in by gravity? It is, of course, not to be forgotten that even if pumped in or forced in by gravity the external atmospheric pressure would assist the flow of water. But, in the instance in question, work was done against the opposing force of gravity and sometimes in summer gravity got the "upper hand," stopped the injection water supply and also the engine and filled the place with steam.

If it could be shown that the vacuum was or should be a trifle less as a result of the water climbing up against the action of gravity it would aid one to understand this problem. I feel that, though it could not be experimentally determined, the energy was supplied by the steam

and that more steam was used than would have been necessary if the water did not have to be lifted. Otherwise one seems to be hovering about some form of perpetual motion and this, we know, is out of the question.

Can anyone give a clear explanation of this problem?

W. H. BOOTH.

London, S. E., England.

Air Receiver Exploded

The shell of a 24x72-in. air receiver, carrying 90-lb. pressure, split from end to end in a straight line along the bottom where the metal had wasted away to $\frac{1}{16}$ in. in thickness, at the end where the rupture started. This wasting seems to have been caused by water carried in by the air in the form of moisture. The interior of the shell was coated with a black ooze. Is this a common occurrence?

GEORGE RUSSELL.

Spring City, Tenn.

Using Inferior Packing

Possibly my experience will interest those who are compelled, by force of circumstances, to use inferior rod packings.

I order all of my supplies through a purchasing agent and usually get what I order, but the last supply of packing received was not the kind I had ordered. It was of such an inferior quality that the maker must have been ashamed to put his name on it, as there was no name nor identifying trade mark to be found.

I packed the main engine piston with it and the trouble that followed almost distracted me. If I pulled the gland up only moderately tight steam would blow through, almost as if there was no packing in the stuffing-box, and if I tightened up on it, it would be smoking hot in a few minutes. Finally I took it all out and put a new ring of it in the bottom of the stuffing-box. Then I took rope asbestos well soaked in cylinder oil and graphite and wound this around the rod, filling the stuffing-box almost full, then I put in another ring of the packing on top of the asbestos rope. I pulled the gland up fairly tight, then slacked it off and screwed the nuts up finger tight and my packing troubles were over. I have now packed the engine three times in this way and one packing lasts about two months. There is not the slightest leakage of steam, and the friction on the rod is negligible. I also find it satisfactory for packing the air piston rods of the air compressors. I concluded it was cheaper to use the packing in this way instead of throwing it all in the scrap pile.

W. G. CAMP.

Rock Crusher, Texas.

Dirty Boiler Indicated by Steam Chart

The two cards reproduced herewith, taken from a recording steam gage, show the importance of keeping the tubes of boilers free from soot. These charts were taken during two days' run and with loads practically the same. The fireman was in the habit of not cleaning the tubes except once a month, and the day came when he "punched" them clean. Nothing was said about the steam until the end of the run at 6 p.m., when his attention was called by the chief to the straight steam line on Fig. 2 in the engine room. Much to the fireman's surprise it was at once decided to investigate the daily record of the number of wheelbarrow loads of fuel used on the day that Fig. 2 was taken, which showed that 56 loads were burned, while the day following, when Fig. 1 was taken, 39 loads only were required.

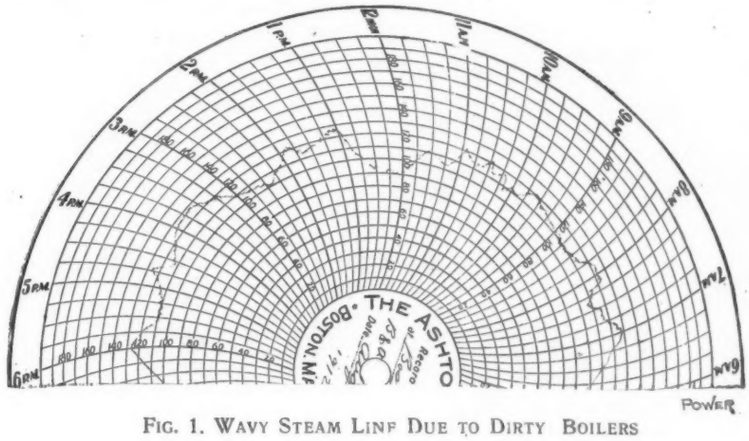


FIG. 1. WAVY STEAM LINE DUE TO DIRTY BOILERS

The damper closes at 126 lb. gage and Fig. 2 shows that the damper was open almost constantly, it being nearly impossible to keep up the pressure. Fig. 1 shows the pressure was maintained uniformly with greatly reduced labor.

The interesting feature of it all is that the fireman did not have the recording gage in mind at any time through the day until he was called to the engine room at night. Therefore, it shows a clear disinterestedness as regards a straight steam line.

It will be noticed on the charts that the run was from 7 a.m. to 12 a.m. and from 1 p.m. to 6 p.m., after which no special pressure is necessary through the night.

A. C. WALDRON.

Revere, Mass.

Cleaning Boiler Fire Boxes

A 50-hp. boiler of the firebox, return-flue type, became incrusted in the water legs with scale and bagged between the staybolts and finally cracked in two places.

The boiler inspector ordered the sides of the firebox bricked up and the water fed from the top at the rear. The four hand plates of the water legs were set in the wrapper sheet so far toward the center of the boiler that it was impossible to use a cleaning tool inside the water legs.

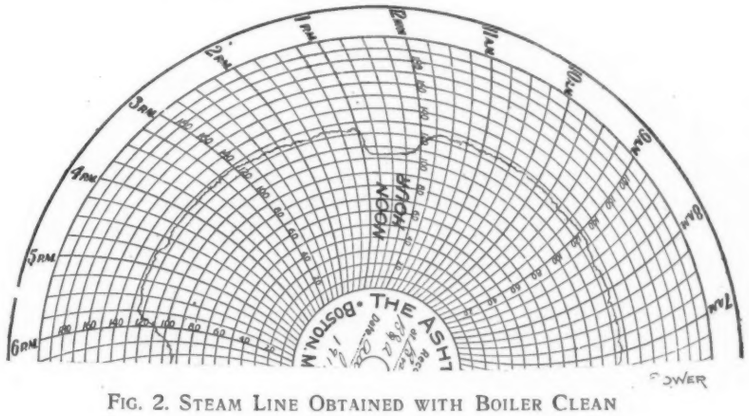


FIG. 2. STEAM LINE OBTAINED WITH BOILER CLEAN

We drilled and tapped the outside sheet for 1¼-in. pipe plugs, and were then able to keep the fire sheets clean by using a small rod scraper. We have had no more trouble with sheets burning since these changes were made, as nearly all the scale has been removed.

PAUL STUART.

Nebraska City, Neb.

Questions Before the House

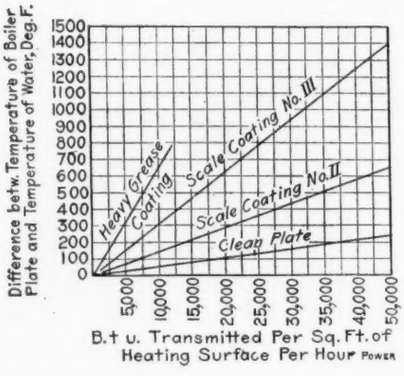
Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Overloaded Boilers

In your editorial, Oct. 29, you very properly point out the dangers incidental to ignorant handling of boilers. The source of danger to which you specifically call attention is not, however, the chief danger, nor the principal cause of boiler accidents. The impression received from reading your editorial is that overloading, that is, forcing boilers to carry peak loads, is a serious menace.

Before accepting this view, however, would it not be well to analyze the processes which go on when a boiler is overloaded?

Overloading, as I understand it, means evaporating more water per hour from each square foot of boiler surface than the boiler is rated to evaporate, involving, of course, the burning of more coal upon the same grates. It will be conceded that the evaporation of more water, involving the transmission of more heat, implies a higher temperature of the boiler plate, but how much higher? This has been studied by several European investigators, and the accompanying chart, prepared by Dr. E. Reutlinger, of Cologne, shows that in the absence of scale or other coating, the rise in temperature of the boiler plates or tubes is very small. For instance, when 40,000 B.t.u. are being transmitted through each square foot per hour, the rise in temperature of the clean plates is only a little over 200 deg. This corresponds approxi-



mately to 40 lb. of water per hour; that is, to 1⅓ hp. per sq.ft., or ¾ of a sq.ft. per horsepower, as against the ordinary builders' rating of 10 sq.ft. per horsepower. As the table shows, however, with scale present the temperature would rise 600 to 1200 deg. or more, which would certainly result in injury to the plate or tubes, and, as Dr. Reutlinger says, "In the interest of safety, the use of softened feed water or frequent boiler cleaning is to be emphatically advised."

We come to the same conclusion, that boilers are ordinarily injured by accumulations of scale, sludge or other coatings, rather than by the mere fact of overdriving, if we examine the statistics collected by boiler-inspection and insurance companies. Of 207,465 boilers examined in 1905 by the Hartford Steam Boiler Inspection & Insurance Co., 117,142, or about 56 per cent., were defective in ways which could be traced to impure feed water, and of 212,211 boilers examined by the same company in the year following, 119,096 were defective from causes due to impure feed water, which is likewise about 56 per cent. of the number examined.

The following table, abstracted from *The Locomotive*, the official organ of the Hartford company, reveals the same fact:

Whole number of defects:	1905	1906	1907	1908	1909	1910
Deposit of sediment	17,757	18,624	18,917	18,829	20,644	19,471
Incrustation and scale	38,965	38,753	38,427	37,924	41,541	43,663
Internal grooving	2,783	2,767	3,010	2,649	3,188	2,830
Internal corrosion	13,109	13,161	12,862	13,053	14,086	13,781
Burned plates	5,181	5,332	4,878	4,605	4,887	5,174
Leakage around tubes	11,768	11,036	11,357	10,929	13,423	13,015
Defective tubes	4,503	7,266	8,266	8,026		9,691
Leakage at joints	6,088	6,005	5,557	4,845		5,956
	100,154	102,950	103,214	100,910		113,581
Number of dangerous defects:						
Deposit of sediment	1,192	1,144	1,315	1,242	1,235	1,367
Incrustation and scale	1,098	1,310	1,333	1,193	1,251	1,468
Internal grooving	235	262	258	249	259	229
Internal corrosion	556	516	528	555	576	611
Burned plates	520	558	499	440	368	478
Leakage around tubes	1,381	1,381	1,599	2,103	2,039	1,789
Defective tubes	1,341	1,912	3,054	2,136		2,508
Leakage at joints	401	364	430	392		353
	6,724	7,447	9,016	8,310		8,883
Total number examined internally	155,024	157,462	159,283	151,359	136,682	138,900

Similar figures from the Fidelity & Casualty Co. are as follows:

	1905	1906
Internal corrosion and pitting	1,722	1,372
Deposit of sediment	747	914
Scale and incrustation	2,815	2,167
Burned plates	136	194
Blistered plates	161	208
Bagged plates	972	707
Leaky tube ends	731	682
Leaky seams	680	647
	7,694	6,951
Total number examined internally	34,046	35,428

From the Maryland Casualty company's report, take the table on the next page.

Finally, is there any reason why we should expect a boiler to be injured particularly by overdriving? Unless the amount of air per pound of fuel, or the grade of the fuel has been changed, the temperature of the gases of combustion will not be altered, but the gases will be supplied to the boiler in much greater quantities, and the hot gases will penetrate farther into the nest of tubes. The boiler, it is true, must disengage steam more rapidly, but this is not so apt to injure the boiler as it is to injure the engine or turbine to which the steam is supplied. The only danger to which overdriving exposes a clean boiler is failure to circulate the water rapidly enough to keep the heating surfaces wet at all times. This is the fault of the boiler designer, but the fact that boilers are being regularly operated at overloads of 200 and 300 per cent. shows that it is not beyond his ability to design boilers to meet these conditions. With free open passages without constricted throats, and with tubes of reasonable length, there is no difficulty in keeping the tube surface wet. This applies to fire-tube boilers as well

An examination of this table shows that a very large proportion of all the defects, that is, deposits of sediment, incrustation and scale, and internal corrosion, are certainly to be attributed to the character of the feed water, while the remaining defects, that is, internal grooving, burned plates, leakage around tubes, defective tubes, and leakage of joints, are in most cases undoubtedly due to the same causes, that is, the plates would not have been burned had not they been insulated from the water by a coating of scale or sludge, and the tubes would not have been injured or have become loose from their fastenings, had they not been overheated, due to the same insulating coating of scale.

	Total defects			Dangerous defects		
	1905	1906	1910	1905	1906	1910
Deposit of sediment	991	835	1,765	155	207	293
Incrustation and scale	2,532	2,535	4,701	358	445	405
Internal corrosion	1,371	1,280	1,877	104	340	189
Pitting	1,495	1,432	1,928	83	217	183
Leaky tube ends	1,778	1,933	2,872	454	516	936
Bulges, sags or bags	857	1,180	2,339	208	281	469
	9,024	9,195	15,482	1,362	2,006	2,475
Total internal inspections	18,395	19,321	26,779			

as to water-tube boilers, as witness the high rate at which locomotive boilers are regularly operated.

Speaking of locomotive boilers, we again here find confirmation of my contention that the injury to the boilers is generally due to scale and not to overloading. In 1902, the Chicago & Northwestern Ry. installed water-softening equipment at 17 stations. The results upon engine performance have been summarized as follows:

	1902	1903
Ton mileage, in million ton-miles	2,934	3,154
Increase in ton-mileage		220
Coal burned per 100 ton-miles lb.	28.7	27.5
Savings coal burned per 100 ton-miles lb.	.....	1.2
Saving in coal (at $3 per ton for 3000 million ton-miles)	.....	$30,000
Average assignment of engines (83 per cent. of which were in constant service both years)	159	154
Saving in assignment of engines	.....	5
Saving in engines (10 per cent. interest and depreciation) on cost of 5 engines at $10,000 each	.....	$5,000
Number of boiler makers employed	36	23
Number of helpers employed	42	30
Total number of laborers on boilers	78	58
Saving in laborers		20 or 26 per cent.
Saving in wages of boilermakers and helpers		$7,700
Saving in material for boiler repairs	Not estimated, but known to be large	
Boiler failures from leaky flues	544	99
Boiler failures from leaky fire-boxes	33	20
Boiler failures from leaky arch tubes	6	1
	583	120
Reduction in number of boiler failures (79 per cent.)		463
Estimated yearly saving to road, all causes		$75,000

A great diminution in the number of boiler failures was obtained by softening the water, but probably without changing the average rate of steaming in any way, or if anything increasing it, due to the greater steam-making capacity of clean boilers.

So far I have considered only the injury to boiler metal due to overheating, but boilers are also injured by corrosion, which can generally be prevented by the same treatment that is employed to prevent scale.

To sum up, then, may we not justly say that boiler disasters are due, not so much to overloading, in the way of hard driving, as to overloading with ignorance and neglect on the part of owners, designers and operators? When these facts are clearly understood in their true significance by all parties concerned, owners will insist that the designers of boiler plants provide for properly treating the feed water, when making the original installation, and that operating men see that such apparatus is properly used to insure the intended results; and on the other hand, intelligent operating men will refuse to work for owners who will not provide equipment for this purpose. It should not be difficult to secure the desired ends, once the situation is clearly understood, since the reduced cost of boiler repairs and replacement, and the fuel saved, will amply repay the cost of treating the water.

WILLIAM B. CAMPBELL.

Philadelphia, Penn.

[If Mr. Campbell will again read the editorial referred to he will find that it aimed to give the impression that overloading boilers is exceedingly dangerous *when they are not cared for properly.* Boilers will carry heavy overloads if kept clean and free from structural defects. This is so generally known, in fact, it is so generally practiced, as to have needed no comment in the editorial. What we did condemn was the practice of heavily overloading boilers as a substitute for inadequate boiler capacity and at the same time grossly neglecting them because the exigencies of the service will not permit taking them out of service long enough to properly clean and examine them.

The editorial said in part: "But these boilers, the best, cannot long perform their function properly if overloaded, forced to the limit and left to care for themselves until so hurriedly examined that serious defects are still undiscovered, when they are again put in service."—EDITOR.]

Graphite in Boilers

Discussion of the use of graphite in boilers was invited by the editorial in the Sept. 17 issue. To that which appeared in the Nov. 19 issue, I would add the following from my experience:

Ideal boiler water is hard to get. If the scale-forming substances are absent the corrosive element is there to eat away the shell and tubes, which, as far as ultimate safety is concerned, is worse than scale. In some localities the water is so good that boilers can be operated an entire year without the necessity of cleaning. Such water is found in many places where the supply is a natural surface water in which the percentage of impurities is so low that no precipitation will adhere to the boiler interior and is just sufficiently saturated to prevent the oxidization which a pure rain water would cause.

Two batteries of nine and ten boilers each in different institutions in the vicinity of Trenton, N. J., fed with artesian well water, contained considerable scale. The analyses of the water showed 10 and 15 grains of incrustating matter per gallon. In one battery compound treatments were tried with varying results. It proved best to have the water analyzed by a disinterested chemist and the compound prescribed and bought in the open market. The analysis disclosed the presence of lime and magnesia carbonates and sulphates in smaller quantities. The scale was considerable in amount, but not very hard. We were advised to use 5 lb. of soda ash and ½ lb. of caustic soda or 6 lb. of caustic soda ash for each 150-hp. boiler. This latter substance costs about 3½c. per lb.

These boilers were fed from a hotwell which received hot water from the apparatus used in the factory. The temperature of the feed water from this source ranged from 100 to 150 deg. F. Some of the boilers were fed through a feed-water heater of the closed type, but the rest had no heater of any kind. For the first the compound was dissolved and fed through a bypass in the feed line. In the boilers having no heater it was the custom to dissolve the compound and throw it into the hotwell once a day, at any convenient time. In neither instance were the results very satisfactory. This compound, as a reagent for neutralizing the scale-forming matter, was the best we had used, yet like the others it made little, if any, progress in the dissolution of the old scale.

On taking charge of these boilers, I found them with scale from ⅛ to ½ in. thick on the shell and tubes. At the heads it was still thicker and thin pieces had collected between the tubes and become cemented into a compact mass extending from 2 to 4 in. from the heads. Tubes were continually leaking and many had to be removed because of being burned.

Several of the boilers had been bagged. In many places the vertical spaces between the tubes were closed. More than half of the tubes in the feed-water heater were closed from end to end. Under these conditions steam could not be kept up and frequently one of the main engines had to be shut down. In cleaning out the hotwell it was found half full of a dirty white sludge, the nature of which was at first not known.

Investigation showed that the compounds were causing the precipitation. Had the compound been used more intelligently by feeding continuously, instead of being thrown in all at one time, better results would have been obtained. The parties selling the compound were

responsible for this method of feeding and there are some who advise it still.

Improvements in the manner of feeding the compound were made. Each boiler was opened once in four weeks, but with continued effort it took three years to get the run of the tubes bare underneath, although the scale on top of them was anywhere from ⅛ to ¼ in. thick. At the heads very little improvement was made, notwithstanding that efforts were made to cut it away with bars and chisels. As the only time available for cleaning was between Saturday night and Sunday night, in which the boilers had to be cooled, cleaned and the fire relighted, they were always too hot for one to stay in them very long.

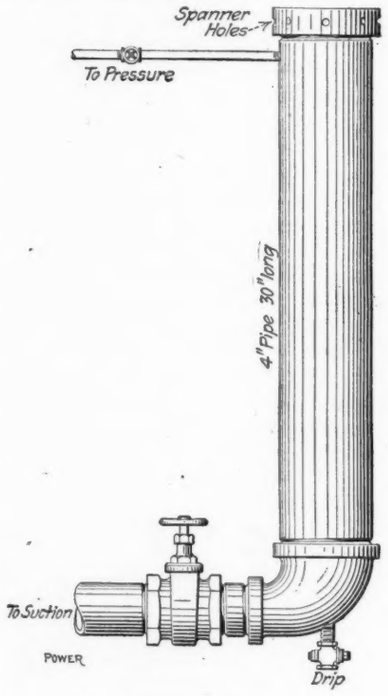
Not being able to convince the management of the value of heater purifiers, water softeners or cleaners for removing scale, all the information possible concerning compounds was sought. Almost everything was advised from sugar to coal oil, among them graphite. As a last resort, before settling down to the inevitable, a trial keg of graphite was ordered. It was difficult to see how such a neutral, insoluble element could have any effect on scale, but it was recommended by a friend whose experience gave his advice much weight. Its use was begun according to directions and results were anxiously awaited.

The first sign was the sound of scale being driven through the blowoff pipe. On opening the boilers for the first time after beginning the treatment a wheelbarrow full of scale was removed from each. Patches of scale here and there were already breaking from the shell, something that rarely occurred before. Apprehension was felt lest the lumps of scale should collect and cause the fire sheets to bulge, but the blowoff was used four times a day and it was found that the scale no longer cemented together or collected on the boiler. This treatment was continued and in about eight months the boilers were pronounced clean by the inspector.

In assuming charge of another plant of ten boilers, fed by deep-well water, the conditions were bad. The scale was hard and the boilers looked as though they were lined with porcelain. The same treatment was begun with the same result—a slow but steady disintegration of the scale. The water in the boilers became saturated and was emptied out of them at least once a month. While no case of priming was observed it is only reasonable to assume that with 20 or 30 lb. of graphite suspended in the water, ebullition could not be as free as with clean water. For this reason and to remove any scale that might have fallen on the fire sheets frequent cleaning was carried on until the boilers were clean; then the amount of graphite fed to the boilers was reduced.

There seems to be but one kind of graphite from which results can be had. It is of an amorphous noncrystalline character capable of being reduced to an impalpable powder, of such fineness that it will float in the air like dust and penetrate the smallest interstices in the scale deposit.

No known chemical action occurs in the use of this material for the removal of scale; its action seems to be so purely mechanical. In the scale deposit minute cracks are made by the expansion and contraction of the boiler and into these openings the graphite finds its way, coating the boiler surface and preventing further adhesion until the cracks unite when the pieces fall away. Obviously, a boiler that is run continuously and



GRAPHITE FEEDER

whose temperature is almost constant will not respond to the use of graphite as well as a boiler that is cooled down and washed out every two or three weeks. When the boiler is cooling, contraction breaks the scale and loosens it in spots, and when the water holding the graphite in suspension is fed into the boiler it readily finds its way into these interstices between and under the scale which sooner or later falls away.

No matter how carefully and thoroughly a boiler is washed out, considerable quantities of scale will fall and it will be necessary to open the blowoff valve frequently during the first 24 hours after raising steam to prevent small particles from choking the blowoff pipe. When the boiler is opened and the water let out a black, pasty looking substance will be found. This is the precipitated scale-forming matter mixed with graphite and it should be washed out before it dries. The boiler should be blown down regularly, the frequency depending upon the character of its service.

Graphite should be fed directly into the boiler and not thrown into tanks, hotwells or cisterns, because it will settle if the water is not in motion.

For feeding graphite the device shown herewith will be found to be all that is required. It is made of a piece of 4-in. pipe (which is large enough for 4 lb. of graphite), with a cap fitted so as to be water-tight on top, the bottom is connected to the suction pipe and is fitted with a gate valve or cock. The small valve at the bottom is for a drip and the ¼-in. pipe at the top should be connected to the pressure side of the pump. When the 4-in. pipe is being charged with graphite it should be half full of water. The graphite should then be thrown in the chamber and more water poured on top until the pipe is full. After the tank is closed the lower valve is opened a little and the upper one just cracked. If the boilers are in a battery, care should be taken that each boiler receives its share of graphite.

Steam from these boilers has been admitted to vessels containing white fabric and also used for cooking, the steam coming in direct contact with the food yet no complaint has been made because of the graphite being carried over with the steam.

Graphite is not a substance that can be used carelessly or with indifference. Unless proper care is taken to keep the blowoff pipe clear and means taken to remove the loosened scale its use is dangerous. Engineers who are not willing to use necessary precautions are advised not to use graphite, because it will bring scale down and sometimes bring it down fast.

WILLIAM HIRST.

Trenton, N. J.

By the blowing out of a nonreturn automatic stop valve, connected between the boiler and the main steam header, the assistant engineer of the Los Angeles, Calif., city lighting plant was so badly injured that he died two hours later.

The engineer had opened the valve from the header to connect No. 1 boiler with the other boilers. According to a report received, he discovered that the valve body was leaking and, calling to the chief engineer, announcing the fact, started for the ladder to descend to the floor, when a piece from the side of the valve, about 3 in. in diameter, blew out, striking him in the chest, throwing him from the top of the boiler to the boiler-room floor, where he struck on his head, fracturing his skull and breaking three ribs and his collar bone.

We are informed by a correspondent that the fractured piece showed no indication of being an old break. It was a trifle less than ¾ in. thick, and the steam pressure was between 175 and 200 lb.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Material for Grinding Valves

What material is good for grinding brass valves?

C. F.

Powdered glass mixed with a light oil to form a paste is one of the best known materials for grinding valves or other brass work.

Appearance of Different Temperatures of Fire

What temperatures of fire on a boiler grate correspond to different appearances of color?

J. B.

According to M. Pouillet, temperatures of fire corresponding to different appearances are as follows:

Red, when just visible	977 deg. F.
Dull red	1290 deg. F.
Dull cherry red	1470 deg. F.
Full cherry red	1650 deg. F.
Clear cherry red	1830 deg. F.
Deep orange	2010 deg. F.
Clear orange	2190 deg. F.
Dull white	2370 deg. F.
Bright white	2550 deg. F.
Dazzling white	2730 deg. F.

Interference of Steam Heating Returns

In a gravity return steam-heating system, how may the returns of coils and radiators which are on the same floor level be connected so that without use of check valves, one coil or radiator will not fill up with water from another?

F. B.

A coil or radiator can usually be protected against flooding from other heating surfaces by having its return dropped low enough before being connected to a return main or to other returns. Good circulation can usually be secured by thus independently dropping returns of the same floor a distance of three or more feet.

Efficiency of Alternator

What is the percentage of efficiency of a three-phase alternator which requires 335 net horsepower for developing 63 amperes in each wire at 2200 volts, the power factor being 95 per cent.?

J. J. B.

The output of the alternator is given in kilowatts by the formula

$$kw. = \frac{\sqrt{3} \times volts \times amperes \times power\ factor}{1000}$$

in which the voltage is that across any two wires and the amperage the amount in each wire. Substituting the values given the formula becomes,

$$kw. = \frac{1.732 \times 2200 \times 63 \times 0.95}{1000}$$

$$= 228.05\ kw.$$

As 1 hp. is equivalent to 0.746 kw., 335 hp. would be equal to $335 \times 0.746 = 249.91$ kw.; therefore the efficiency of the alternator is

$$\frac{(228.05 \times 100)}{249.91} = 91\tfrac{1}{4}\ per\ cent.$$

Reversing Turbine Driven Shafts

Is there any practical method of reversing a turbine engine, and what is the means employed for reversing turbine driven steamship shafts?

H. P.

To reverse a steam turbine would require the direction of the nozzles and blading to be reversed, and although possible, in the present stage of turbine development, seems hardly practicable. The method employed in marine practice for reversing the motion of steam turbine-driven shafts is to provide an auxiliary turbine on the same shaft as the ahead turbine, with the blading of the reverse-motion turbine set appropriately for astern motion, steam being admitted to one turbine at a time according to the direction of motion desired, the turbine which is out of use being carried idle.

Vacuum Required for Steam Heating

What vacuum should be maintained in the return line from the heating system of several buildings?

E. T. B.

The requirements vary with different plants and conditions, but generally no more vacuum should be carried at the pump than is necessary to insure the desired activity of circulation in the system. A very small drop in pressure is usually sufficient for good operation of coils and radiators, but in most plants the sizes of return pipes are generally so small that to obtain a perceptable drop of pressure at the heating surfaces 5- to 10-in. vacuum has to be maintained at the discharge end of the returns. Satisfactory results are usually obtainable with 10 or less number of inches of vacuum and in most plants where engine exhaust is used for supplying steam to a vacuum system, no advantage is derivable from carrying more vacuum for the purpose of reducing back pressure on the engine.

Size of Feed Pump

What would be the size of cylinder required for a single double-acting feed pump with 5-in. stroke; having piston rod 1 in. in diameter making 60 single strokes per minute, working with 10 per cent. slip and having capacity to supply by continuous feeding a boiler evaporation of 4000 lb. of water per hour?

W. J.

Evaporation of 4000 lb. of water per hour would be at the rate of $\frac{4000}{60} =$ 66.66 lb. per min. Taken at 62 deg. F., 1 cu.in. of water weighs 0.03609 lb. and

$$\frac{66.66}{0.03609} = 1847.04\ cu.in.$$

of feed water would be required per minute. Allowing 10 per cent. slippage, the pump would have to make an actual piston displacement of

$$\frac{1847.04 \times 100}{90} = 2052.26\ cu.in.$$

per minute.

The displacement on one side of the pump piston would be reduced during 30 strokes per minute by the volume displaced per stroke by the piston rod. The diameter of the rod being 1 in., its area is 0.7854 sq.in. and for 5-in. stroke and 30 strokes per minute the total reduction of piston displacement, due to the rod, would be $0.7854 \times 5 \times 30 =$ 117.81 cu.in. Adding this to the net piston displacement required gives 2052.26 + 117.81 = 2170.07 cu.in. total volumn of cylinder to be displaced per minute. There being 60 strokes per minute and 5 in. length of stroke the lineal displacement per minute would be $60 \times 5 = 300$ in., and, therefore, the cross-sectional area of the cylinder should be $\frac{2170.07}{300} = 7.2335$ sq.in. area, which corresponds to

$$\sqrt{\frac{7.2335}{0.7854}} = 3.03\ in.\ diameter$$

Therefore under the conditions a 3x5-in. pump would be required.

Engineers' Study Course

Simple Lessons and Lectures for Home Study

Ratio and Proportion

If of two pocket knives one cost a dollar more than the other, we should consider that there was a big difference in price, but if of two boilers one cost a dollar more than the other, we should consider that there was very little difference in price. The dollar has the same value in both cases, and the dollar saved by not paying twice as much as a knife is worth would not buy more tobacco than a dollar, which is such a trifle of the whole cost of a boiler.

The difference in these two cases is that the dollar bears a widely different *ratio* to the total cost. In the case of the knife it might equal or even exceed the total cost of the tool, but in the case of a boiler of usual size it would be but a very small fraction of the total cost.

From the above comparison we now know that

Ratio is the relation that exists between two quantities.

There are two kinds of ratio—the *arithmetical* that considers numbers in their differences as, $8 - 6 = 2$, and *geometrical* that is the quotient of one number or quantity divided by the other, as $\frac{6}{2} = 3$.

A series of numbers are said to progress in an arithmetical ratio when the differences between any two numbers is the same, as

1, 2, 3, 4, 5, 6; or 1, 3, 5, 7, 9;

while a series of numbers progresses in a geometrical ratio when the quotient of any two numbers in the series divided by the preceding number is the same, as 2, 4, 8, 16, 32, 64; or 2, 6, 18, 54, 162.

When the word *ratio* is used alone, a *geometrical* ratio is always understood, that is, the part that one number is of another. Thus the ratio of 4 to 8 is 2, of 10 to 5 is ½, etc. This can be expressed in the form of a fraction as:

$$\frac{8}{4} = 2;\ \frac{5}{10} = \frac{1}{2};$$

or, by placing the two dots between them, thus, 4: 8 10: 5.

In either case they are read "the ratio of 4 to 8" and "the ratio of 10 to 5. The dots are commonly used.

The *Terms* of a ratio are the two numbers compared.

The *Antecedent* is the first term.

The *Consequent* is the second term.

A *Direct Ratio* arises from dividing the consequent by the antecedent. Thus the direct ratio of 5 to 15 or $5:15 = \frac{15}{5} = 3$.

An *Inverse Ratio is obtained* by dividing the antecedent by the consequent. Thus the inverse ratio of 5 to 15 or 5: $15 = \frac{5}{15} = \frac{1}{3}$.

All ratios are understood to be direct unless otherwise specified.

Sometimes an inverse ratio is called a *reciprocal ratio.* The *reciprocal* of a number is 1 divided by that number as, $1 \div 8 = \frac{1}{8}$. Here the reciprocal of 8 is ⅛.

A *Simple Ratio* consists of a single couplet, as 3: 12.

A *Compound Ratio* is the product of two or more simple ratios. Thus the compound ratio formed from the simple ratios 3: 6 and 8: 2 is

$$\frac{6 \times 2}{3 \times 8}$$

$$3 \times 8 : 6 \times 2 = \frac{6}{3} \times \frac{2}{8} = \frac{12}{24} = \frac{1}{2}$$

Here we have two ratios, that between 3 and 6 and that between 8 and 2. Writing them in the fractional form, and multiplying, we have the fractional representation of a new ratio, namely, that of the new compound denominator to the new compound numerator, which is found by multiplying and reducing, to be ½ or 2: 1.

To find the ratio between two numbers divide the consequent by the antecedent.

$$Ratio = \frac{consequent}{antecedent}$$

Example: In a boiler having a grate 5 ft. square and 790 sq.ft. of heating surface, what is the ratio of grate to heating surface?

The grate surface, $5 \times 5 = 25$ sq.ft., is the antecedent and the heating surface, 790 sq.ft., is the consequent, then the

$$Ratio = \frac{790}{25} = 31.6\ ans.$$

Rule: *To find the antecedent divide the consequent by the ratio.*

$$Antecedent = \frac{consequent}{ratio}$$

Example: What must be the length of an engine crank in order that the ratio of the crank to the connecting-rod shall be 7, when the rod is 12 ft. long?

Here the ratio is 7, the consequent 12 and the antecedent or crank $\frac{12}{7} = 1\frac{5}{7}$ *ft.*

To find the consequent, multiply the antecedent by the ratio.

$$Consequent = Antecedent \times Ratio$$

Example: The ratio of the diameter of a circle to its circumference is 3.1416. What is the circumference of a circle having a diameter of 4 in.?

In this example 4 is the antecedent and 3.1416 is the ratio, and the circumference or consequent is

$$4 \times 3.1416 = 12.5664\ in.$$

Always express a ratio in the most convenient form, i.e., if we have the ratio 48: 24 we should reduce it to 2: 1. This does not change the value, since 24 goes into 48 two times and 48 is therefore twice as great as 24.

Proportion

We know things by their differences. No comparison of two numbers can be fully explained except by instituting another comparison. The mind does not grasp the relation of 4 to 8 from being told that their ratio is 2 until it is understood that in saying that the ratio of 4 to 8 is 2, we mean that 4 bears the same relation to 8 that *one* or unity bears to 2. The ratio is, therefore, the *consequent* of another pair of terms, having the same relation to each other as the first pair, and the antecedent of which is unity, as

$$4:8 = 1:2$$

or 4: 8: : 1: 2, which is read 4 is to 8 as 1 is to 2. Or better, the ratio of 4 to 8 equals the ratio of 1 to 2.

Numbers which have to each other such an equality of ratio are said to be in the same proportion. From this statement it is obvious that 4 bears the same proportion to 8 that 3 does to 6, the ratio being 2 in each case. This would be expressed

$$4:8 = 3:6$$

and this arrangement of figures is called a proportion and the purpose of proportion is to enable one to find a fourth or unknown quantity when three other quantities are given or known. The unknown quantity is always designated by the letter X, as

$$4:8 = 3:X$$

From the foregoing we see that a *proportion is a statement of equality between two ratios.*

The Extremes of a proportion are the first and fourth, or the outside terms.

The Means of a proportion are the second and third, or the inside terms

$$4:8::3:6$$

In the above proportion 4 and 6 are the extremes and 8 and 3 are the means.

A proportion is made up of ratios and each ratio of any proportion is called a *couplet.* In the above proportion 8: 4 is a couplet and 3: 6 is also a couplet.

Three numbers may be in proportion when the first is to the second as the second is to the third, as in

$$3:9:27$$

where the ratio of each couplet is 3. In this case the second term is said to be the *mean proportional between* the other two. It is simply a common proportion in which the two terms of the means are alike, and could have been written

$$3:9::9:27$$

The chief thing to remember about proportion is that

The product of the means of any proportion is equal to the product of the extremes.

Thus in the above proportion.

$$9 \times 9 = 81 \text{ and } 3 \times 27 = 81$$

From this it is readily seen that if any three terms of a proportion are given the fourth may be easily found by observing the following:

RULE: *Divide the product of the extremes by one of the means and the quotient will be the other mean.* Or,

Divide the product of the means by one of the extremes and the quotient will be the other extreme.

Simple Proportion is an equality of two simple ratios and consists of two couplets and four terms, any three of which being given, the fourth may be found as above.

EXAMPLE: A 60-in. pulley on a line shaft is belted to a 32-in. pulley on a countershaft. The pulley on the line shaft is to be changed to 45 in., but the speed must not be changed. What will be the diameter of the new pulley on the countershaft?

We realize immediately that to maintain the same speed the ratio between the pulleys after the change must be the same as before the change. Let x represent the size of the new driven pulley, then we get the proportion

$$60:32::45:x$$

Here an extreme is missing and we can find it by dividing the product of the means by the given extreme

$$\frac{32 \times 45}{60} = 34 \textit{ in.}$$

Whenever possible, apply cancellation in working out problems in proportion.

Inverse Proportion is the comparison between a direct and an inverse proportion.

The safety valve affords a good illustration of this, as the pressure necessary to lift a lever safety valve is inversely proportional to the distance of its application from the fulcrum, for as the distance from the fulcrum is decreased the necessary pressure is *increased.* If the pressure necessary to lift one valve with the stem 3 in. from the fulcrum was 60 lb., the pressure necessary to raise a valve of the same kind and size but with the stem 2 in. from the fulcrum would be to 60, not in the ratio of the old distance to the new, $3:2 = \frac{3}{2}$, but in the inverse ratio or $2:3 = 1\frac{1}{2}$, i.e., the new pressure would be to the old pressure as the old distance is to the new distance.

If we call the new pressure x we may express this as:

$$3:2::x:60$$

Now multiplying the extremes and dividing by the given mean, we have

$$\frac{3 \times 60}{2} = 90 \textit{ lb.}$$

In all calculations in proportion one must first make sure of what it is that must be found. This particularly applies in calculations involving inverse proportion, as sometimes it is not readily known whether the proportion is direct or inverse.

One can make sure as to whether the proportion is direct or inverse by being sure of what is to be found, and then state the proportion as direct. Then if the first term is smaller than the second, the third term should be smaller than the fourth, or if the first term is larger than the second the third should be larger than the fourth.

Compound Proportion is simply a statement which contains more than two couplets. In compound proportion as in simple proportion there is one third term which is of the same denomination or kind as the fourth or the required term, but there may be two or more first and second terms. After setting down the third term, take each pair of terms of the same kind separately and arrange them as first and second term, making the greater term the second term if this pair considered alone should require the answer to be greater. Then multiply all the first terms together and do the same with the second terms.

Multiply the product of all the second terms by the third term and divide the last product by the product of all the first terms.

EXAMPLE: If two men remove 3 cu.yd. of earth in one day, working 10 hr. per day, how many men working 8 hr. per day will remove 20 cu.yd. in 3 days?

Remember we wish to find the number of men.

Here we have 3 days: 1 day, 3 cu.yd.: 20 cu.yd. and 8 hr.: 10 hr. Multiplying all the first terms we have

$$3 \times 3 \times 8 = 72$$

And multiplying all the second terms we have

$$1 \times 20 \times 10 = 200$$

Now we have the proportion

$$72:200 = 2:x$$

The third term 2 men was given and the fourth term x or number of men required is

$$\frac{200 \times 2}{72} = 5\tfrac{8}{9}, \textit{ say 6 men.} \quad \textit{Ans.}$$

THE UNIT METHOD

Problems in proportion can easily be worked out by what is called the *unit method,* an example of which is given below.

EXAMPLE: If a concrete block for an engine foundation is 15 ft. long, 5 ft. wide and 5 ft. thick, and weighs say 52,500 lb., what is the weight of a concrete block 18 ft. long, 6 ft. wide and 8 ft. thick.

Now, if a block 15 ft. long, 5 ft. wide and 5 ft. thick weighs 52,500 lb., a block 1 ft. long, 5 ft. wide and 5 ft. thick will weigh $\frac{52,500}{15}$ lb., and a block 1 ft. long, 1 ft. wide and 5 ft. thick will weigh $\frac{52,500}{15 \times 5}$ lb., and a block 1 ft. long, 1 ft. wide and 1 ft. thick weighs $\frac{52,500}{15 \times 5 \times 5}$ lb. This fraction is the *unit* we have been looking for.

Now, by a reverse process of reasoning we find that a block 18 ft. long, 6 ft. wide and 8 ft. thick will weigh, this *unit,* multiplied by each of the dimensions of the new block, or

$$\left(\frac{52,500}{15 \times 5 \times 5}\right) \times 18 \times 6 \times 8 = 120,960 \textit{ lb.}$$

What we really did in this problem was to find the weight per unit of volume of the old block and then multiplied this unit by the volume of the new block to find the weight of the new block.

EXAMPLES FOR PRACTICE

(1) A boiler has a grate 4½ by 5 ft. and has 745 sq.ft. of heating surface. What is the ratio of grate to heating surface?

(2) The ratio of the width to the height of a chimney is 10. How wide is the base if the height is 175 ft.?

(3) If 14 tons of coal cost $60, what will 20 tons cost at the same rate per ton?

(4) On an engine having a 48-in. stroke, a lever is used the length of which from its point of suspension to the point of its attachment to the crosshead is 72 in. How far from the point of suspension must the pin for the indicator cord be placed to give a diagram 4 in. long?

(5) A pump discharging 20 gal. per min. fills a tank in 24 hr. How long will it take to fill the tank if the pump discharges 42 gal. per min.?

(6) A column of water 18 ft. high exerts a pressure of 41.4 lb. per sq.in. What pressure will be exerted by a column 72 ft. high?

(7) At what distance from the fulcrum must a weight of 32 lb. be placed to balance a weight of 12 lb. 16 in. from the fulcrum?

(8) If with a safety valve the valve of which is 4 in. from the fulcrum, 60 lb. pressure is required to raise the valve, what pressure would be necessary to raise the valve if it was 2 in. from the fulcrum?

(9) If 6000 gal. of water flow through a pipe in 1 day of 8 hr., how many gal-

lons will flow through 4 such pipes in 4½ days of 9¾ hr. each?

Work out the last problem by the unit method.

ANSWERS TO LAST WEEK'S PROBLEMS

(1) 12,609 B.t.u.
(2) 60,480 lb.
(3) 25 per cent. loss.
(4) 30.68 tons received.
(5) $882 actual price.
(6) 72 lb.
(7) Yes; $\frac{9}{16}$ of 1 per cent.

Refrigerating Engineers' Annual Convention

On Dec. 2 and 3, the American Society of Refrigerating Engineers held its eighth annual convention at its headquarters in the Engineering Societies Building, New York City. A number of excellent papers were presented, and the meeting was well attended.

Routine business and the reports of the election tellers occupied the morning session on Monday. Officers elected to fill the vacancies occurring this year were: President, Peter Neff, Canton, Ohio; vice-president, Theodore Kelischer, Philadelphia, Penn.; treasurer, Frank A. Home, New York City; directors, Carl Behm, New York City; Ezra Frick, Waynesboro, Penn.; Thomas Shipley, York, Penn.

President Shipley opened the afternoon session with an address on the "State of the Art." As a man "on the firing line," he spoke of the work of the manufacturing corps. The service was active and it required the concentrated effort of the artillery, infantry and officers to progress. The advance made in raw-water plants and evaporative systems was briefly mentioned and reference made to the Bureau of Standards appropriation for determining refrigerating constants.

He favored the standardization of ammonia fittings, and while urging the highest economy practical in refrigerating systems, he questioned the advisability of installing complicated machinery and apparatus to save a little fuel without giving due consideration to the life and initial cost of the plant. The coming congress of refrigeration shared his remarks and he appealed to the men in the field to show the visiting engineers America's best in refrigerating work.

"Liqgas; a Possible New State of Matter," by Gardner T. Voorhees, was the first paper read. The author has observed that CO_2 in passing from a liquid to a gaseous state had the appearance just above the critical point of a clear, colorless syrupy gas, resembling hot air with distinct lines of movement. He believed this to be a new state of matter probably common to all substances at or near the critical point. While in this condition the matter was neither liquid nor gas, so the author proposed the name "liqgas." In the discussion it was pointed out that there was nothing new in the phenomena observed and that to call it a new state of matter was unnecessary.

At the sixth annual meeting of the society, R. H. Tait read a paper on "A Gas Producer Operated Refrigerating Plant," mentioning a number of troubles which had developed. In the second paper E. W. Gallenkamp, Jr., related briefly the changes that were made to overcome these troubles and also submitted some interesting results obtained from tests of the plant.

In the discussion, producer-gas engines were not favored for the refrigerating plant, particularly those drawing gas from bituminous producers. Internal-combustion engines using oil or natural gas had operated continuously with satisfaction and might be used. If the compressor was designed for the speed of the engine direct connection would be feasible, otherwise belted units must be installed, or if a more flexible arrangement is desired a generator and motor might be placed to advantage between the engine and compressor.

An animated discussion on the use of ice in refrigerator cars in winter to prevent freezing of perishable products in transit and on the loss of refrigeration at doorways of refrigerated rooms closed the session.

In the evening, Louis Block read his paper on "Avoidable Accidents in Refrigerating Plants." He showed how an explosion might readily occur and how it could be avoided when testing the piping with high air pressure before charging the system with ammonia. Leaks in the engine room might occur with impunity unless the vapor and hydrogen from the ammonia come in contact with the open flame of an arc or gas light. Incandescent lamps would prevent such an accident. He told how breaking the compressor, breaking the crosshead of the steam engine or freezing the connecting-rod brasses to the crankpin may be prevented, and in conclusion gave a few "dont's" well worth heeding.

"Ammonia Compressor Safety Devices" was the title of the paper read by Peter Neff, the newly elected president. Protection against breakage of parts and damage from explosions, unusual pressures, pressure of liquid in the compressor, etc., were sought and obtained in numerous ways outlined by the author.

N. H. Hiller's paper on "The Manufacture of Distilled Water Can Ice" gives the particulars of elaborate tests of an exhaust-steam evaporator ice-making plant at Muncie, Ind., burning different kinds of coal. With one sample a result as high as 11.25 lb. of ice to 1 lb. of coal was obtained. The method of testing and the deductions made from the results are of interest. Following the paper discussion arose as to the ease of cleaning boiler and evaporator tubes with but little advantage on either side.

Other papers were "Atmospheric Dehumidifying," by J. I. Lyle, and "Corrosion in Refrigerating Systems," by Morgan B. Smith. In the latter paper conditions conducive to corrosion were outlined and results given of tests to show the behavior of numerous metals in brine.

The afternoon session was devoted to a discussion of the properties of anhydrous ammonia. Lionel S. Marks and F. W. Loomis presented a paper analyzing the results of the most important experimental work published so far, and discussing critically the tables prepared by various authorities. Wobsa's table on the properties of ammonia was considered the best data available.

A second paper by William E. Mosher, presented through the courtesy of the American Society of Mechanical Engineers, went still further. Not only were available data collected and correlated, but formulas to express the various properties were proposed. The constants in the various formulas were determined by aid of experimental data. No working tables were given, but such papers have been prepared for both the saturated and the superheated vapor. These with a Mollier diagram for ammonia will appear shortly in a bulletin of the engineering experiment station of the University of Illinois.

In a topical discussion on "Things New in Refrigerating Practice," Louis Block and Thomas Shipley told about their improved types of condenser. In the Block condenser the gas is introduced at the bottom and the liquid discharged from the top. When the valve admitting the gas is properly set, each lineal foot in this condenser does three to three and one-half times as much work as in the ordinary condenser. Mr. Shipley improved the efficiency of his condenser by installing a device similar to an injector through which ammonia vapor and liquid pass to the coils.

As a matter of final business it was decided to appoint a committee of three to confer with a similar committee of the American Association of Refrigeration on the advisability of standardizing flanged fittings. The selection was left to the president.

A banquet in the evening at Louis Martin's closed a very successful meeting.

Up to the present time, the total horsepower of marine turbines of the Parsons type, completed and under construction, and of licenses of the Parsons Foreign Patents Co., Ltd., is about 8,500,000 hp., an increase during the year of about 2,100,000 hp. Nearly 7,200,000 will propel warships and over 1,300,000 will be employed by yachts and the mercantile marine.—*Engineering.*

The American Society of Mechanical Engineers

The thirty-third annual meeting of the American Society of Mechanical Engineers, was held in New York during the week ending Dec. 7. The professional work was profuse and comprehensive and the social features, while somewhat of a departure, were in keeping with the traditions of the society and satisfying to and enjoyed by those in attendance.

The volume of the work of the meeting was greatly increased by the activities of the special committees, which, with hearings and discussions of partial and provisional reports, as well as in their finished contributions to the program, had the greatest effect that these embryo sections have yet exerted upon the work of the society.

The address of the retiring president, Alexander C. Humphreys, "The Present Opportunities and Consequent Responsibilities of the Engineer" dealt largely with the relations of the engineer to the public. On account of the abandonment of the usual reception at the Hotel Astor on Thursday evening, the reception following the delivery of the address on Tuesday evening took on increased importance.

Wednesday forenoon was devoted to a business session in which the reports of the council, and various committees were considered. Amendments to the constitution, introducing a new grade of membership, the "Associate," intermediate between the junior and the full member, transferring the function of deciding upon the admission of a candidate from the membership to the council and making the Committee on Constitution and By-Laws a standing committee were assigned for letter ballot.

The report of the tellers of election announced the selection of the following officers: President, W. F. M. Goss; vice-presidents, James Hartness, I. E. Moultrop, H. G. Stott; managers, W. B. Jackson, H. M. Leland, Alfred Noble; treasurer, William H. Wiley.

The new president, William Freeman Myrick Goss, was born at Barnstable, Mass., in 1859, studied at the Massachusetts Institute of Technology 1877-9, took the degree of master of science at Wabash in 1888 and doctor of engineering at the University of Illinois in 1904. He organized the department of practical mechanics at Purdue University in 1879, and was professor of expermental engineering, dean of the school of engineering and director of the experimental laboratory of that institution from 1890 to 1907, giving special attention to the testing of locomotives. Since that time he has been dean of the College of Engineering of the University of Illinois. He was a member of the Jury of Awards in the Chicago Exposition of 1893, expert in charge of the mechanical exhibit, Land Grant Colleges and chairman of the advisory committee of the Pennsylvania Ry. Co., charged with testing locomotives at the St. Louis Exposition of 1904. He is a fellow of the American Association for the Advancement of Science, member of the International Society for Testing Materials and of the Society for the Promotion of Engineering Education and ex-president of the Western Railway Club.

The report of the council showed a gratifying increase in the membership of the society.

Following the business session, a Power Plant Session had been arranged for the main auditorium, while the Gas Power Section held an interesting and well attended session which will be covered in our Gas Power Department in the issue for Dec. 24, and in still another hall a Textile Session under the auspices of the subcommittee on Textiles, was held, at which, among other papers, was one presented by John A. Stevens, of Lowell, on "The Power Plants of Textile Mills."

W. F. M. Goss

The following officers were elected by the Gas Power Section for the ensuing year: Chairman, F. R. Hutton, one year; Executive Committee, W. B. Owens, five years; W. A. Blauvelt, three years; H. J. Freyn and C. H. Benjamin, one year.

At the Power Plant session the first paper presented was "Dimensions of Boiler Chimneys for Crude Oil," by C. R. Weymouth. Chimneys suitable for coal fuel are larger than needed for oil fuel, and tables of dimensions of the former are of no use where oil is to be burned. A single table cannot be compiled, but the paper gives the elementary principles for determining the correct dimensions under any given set of conditions. The dimensions given are for sea level and at various altitudes with correcting factors for fuel economizers.

This paper was discussed by William Kent and E. H. Peabody, who referred to the importance of having every burner properly adjusted and the furnace of right design for oil burning.

"Tests of a 1000-hp., 24 Tubes High B. & W. Boiler," by B. N. Bump, was the next paper, and described tests on an inclined-header Babcock & Wilcox boiler with superheater and mechanical stoker. The peculiar feature of the boiler was the unusual height, the sections being 24 tubes high. The best combined efficiency was obtained at about 56 per cent. of rating and decreased slowly with an increase in rating.

Prof. W. D. Ennis remarked the extremely low evaporation rate given—below 2 lb.—and the unusual ratio of heating to grate surface and believed that the large heating surface should have more completely absorbed the furnace heat. William Kent called attention to the diagram in the paper confirming what has been generally found, that there is a slight decrease in efficiency with increased rate of driving, and that the decrease will be less the more nearly the proper theoretical conditions are obtained for the ratio of air to combustible. He thought the boiler would have given better efficiency if the air supply had been exactly right, which would have been shown by an analysis for the oxygen in the gases. J. N. Browne commented on the system of baffles used, employing asbestos board and regretted that furnace temperatures were not given as they would have thrown more light on the results. D. S. Jacobus added to the discussion some remarks on the common mistake of not getting the true amount of CO. He was satisfied that the analyses given in the paper were correct. He spoke also of the difficulties in getting above 10, 11 or 12 per cent. of CO_2, and the indefiniteness of most temperatures as obtained in a furnace as they vary so much with where or how they are taken.

The session adjourned for luncheon recess to reconvene in the afternoon, when the discussion of Mr. Bump's paper was resumed. C. D. Young spoke of superheater experiments in locomotive practice, noting some confirmation of their conclusions in Mr. Bump's paper and asking what the experience was relative to the effectiveness of heat transfer to the water-heating surface as compared with that to the superheating surface. The speaker's results had indicated that the latter is only about half as effective as the former.

"Air in Surface Condensation," by George A. Orrok, the next paper, is an addition to the same author's paper on

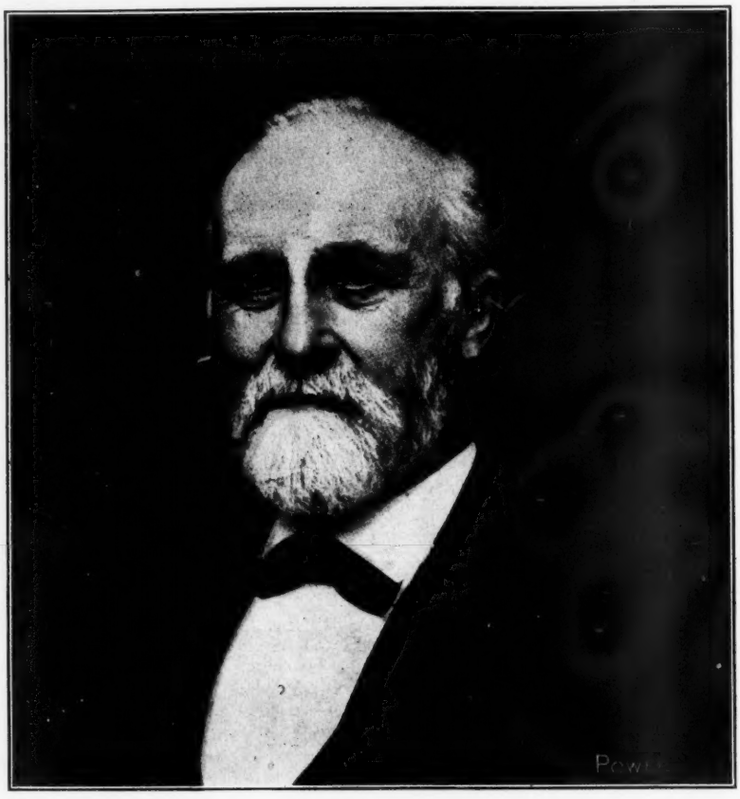
the "Transmission of Heat in Surface Condensers" previously presented before the society. It gives the results of his investigations on the amount of air present in feed water and the presence and effect of air in surface condensers and described an apparatus for measuring the air leakage. This paper was discussed by George J. Foran and E. W. Christie.

The next two were papers also presented before the American Society of Refrigerating Engineers and are alluded to in a report of that society's meeting on another page of this issue. They were "Properties of Saturated and Superheated Ammonia," by William E. Mosher, and "Physical Properties of Anhydrous Ammonia," by L. S. Marks and F. W. Loomis.

This session was concluded with two papers that passed without discussion. "Experiments with North Dakota Lignite in a Steam Power Plant and a Gas Producer," by Calvin H. Crouch, and the "Baltimore Sewerage Pump Valve," by A. F. Nagle.

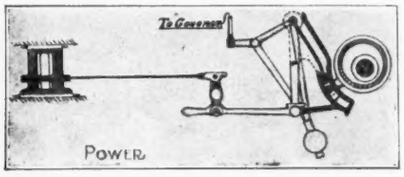
Wednesday afternoon had been assigned to the reception and discussion of reports of technical committees, including Power Tests, Hoisting and Conveying, Standard Cross Section Symbols, Involute Gears, Standardization of Catalogs, Flanges, Pipe Threads and others. The most extensive and important of these was a preliminary report from a subcommittee of the Committee on Tests. This report occupied 190 pages of the November issue of the *Journal* and would require a complete session for its comprehensive discussion.

It was regretable that this, perhaps the most important feature of the program from the point of view of the power-plant engineer, was crowded to the end of a busy session taken up at a time when the limited number present were satiated with a day of attendance and under conditions, which tended to discourage rather than to bring out discussion. It is impossible to reproduce this report in POWER. It will be the basis of American practice in general testing work just as the former reports of the Committee on Boiler Testing has been for that particular division of the subject, and ought to have the exhaustive consideration of power-plant engineers before it is accepted as expressing the concrete views of American engineers. We shall treat it at some length in a later issue.



JOHN E. SWEET

On Wednesday evening a testimonial dinner was given to Prof. John E. Sweet, honorary member and past president of the society, in celebration of his eightieth birthday. Dr. A. C. Humphreys, Capt. Robert W. Hunt, Prof. Albert W. Smith and Dr. John A. Brashear were the speakers. The picture reproduced here-

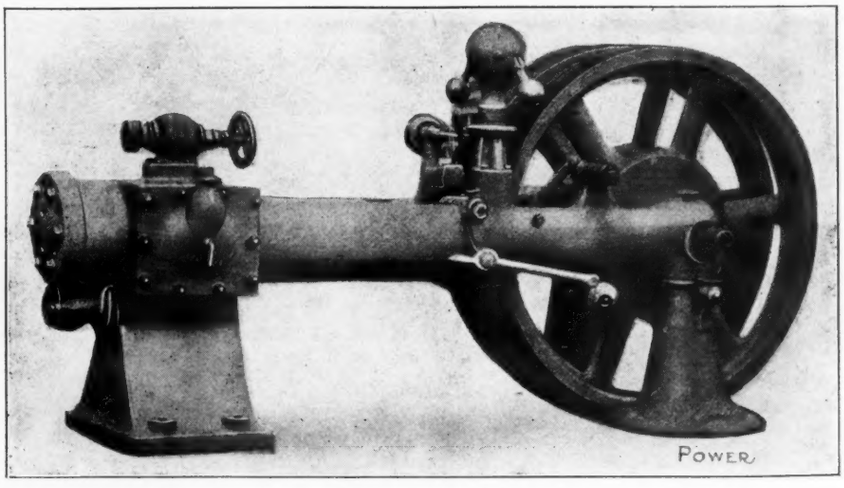


VALVE-GEAR DIAGRAM

with of his original Straight-Line engine, as used in the mechanical laboratory of Sibley College, where he taught, adorned the menu. The designs, drawings, patterns and a good part of the machine work on this engine were made by Professor Sweet between Thanksgiving Day, 1871, and Apr. 1, 1872. This photograph was donated to the society by Mrs. Davis, widow of R. H. Davis, who did the rest of the machine work.

On Thursday forenoon the session in the main auditorium was devoted to the discussion of papers contributed by the subcommittee on Machine Shop Practice. Railroad and Cement sections held simultaneous meetings.

On Thursday afternoon the session in the main hall was devoted to papers dealing with the flow and measurement of fluids.



FIRST STRAIGHT-LINE ENGINE

The ladies served tea on Wednesday and Thursday afternoons in the rooms of the society.

On Thursday evening the society joined with the civil, mining and electrical engineers in the ceremonies attending the award of the John Fritz medal to Robert Woolson Hunt, past president of the society, "for his contribution to the early development of the Bessemer process." Following the presentation, a joint reception to Mr. Hunt and to the members and ladies of the four societies was held.

Friday was devoted to Industrial Management under the auspices of the subcommittee on Administration. This subject, always provocative of discussion, occupied well attended sessions both morning and afternoon.

During the meeting a number of special committees were busy, two of which, those upon Safety Valves and Standard Boiler Specifications, promise to develop material of special interest to POWER readers. The papers with the discussion evolved which are of special interest in our field have been or will be presented in other issues.

As professional sessions were in progress throughout the meeting—morning and afternoon—the excursion program had to be made up without regard to them and in consequence most of the trips were ill attended.

Wednesday afternoon there were two excursions; one to the Grand Central Terminal, where the new construction there under way was inspected, and another to the Waterside station of the New York Edison Co.

Thursday morning the Ellis Island Immigrant Station was visited and the Aquarium. In the afternoon one party inspected the present state of work on the Fourth Ave. Subway in Brooklyn and another visited the Keller Mechanical Engraving Co., where opportunity was given to see the processes of making dies for silverware and the special machines for kindred engraving work. Still another party inspected the Bush Terminal in Brooklyn with its elaborate system for shipping and receiving freight and handling it to and from the various factories and warehouses at the terminal.

A trip to the Navy Yard, Friday morning, always interesting, was especially so this time, as the party was able to go all over the "Wyoming," the largest battleship in commission and then in drydock, and the "New York," recently launched and now being equipped, which will be the largest battleship. At the same time an excursion was made to the works of the August Griffoul Brothers Co., in Newark, N. J., which makes very fine castings of gold, silver, bronze, iron, etc., including commercial and art work, such as bas reliefs and statuary.

Friday afternoon, the Pennsylvania R.R. entertained a party at its terminal, showing the train- and mail-handling systems, power plant, and including a trip in a multiple-unit train through the tunnel to the Sunnyside yards on Long Island.

A number of additional excursions were also provided that individuals might take at their own election. These included power plants, large and small, industrial plants of various kinds, the museum of safety devices and a collection of ancient and modern firearms.

National Gas Engine Association Convention

The fifth annual convention of the association was held at the Claypool Hotel, Indianapolis, Ind., Dec. 3, 4 and 5, the meeting being the most important held since the organization of the society.

The feature of the first day was the opening address by the president, O. C. Parker, in which he laid before the members for discussion two principal questions: The matter of a uniform rating formula and the desirability of a salaried secretary for the association who would devote his whole time to promoting the interests of the gas-engine industry.

The opening paper of the second day was the "Present Status of the Gas Turbine," by Prof. C. D. Wagner, of Rose Polytechnic Institute. Prof. Wagner first reviewed the work of Armengaud, who built a 300-hp. turbine of the constant-pressure type in 1906. As this machine used six times the fuel required by the ordinary gas engine its commercial impossibility was at once recognized. He then gave in some detail the work of Hans Holzwarth who has recently realized 20 per cent. thermal efficiency in a machine of the explosive type developing 450 hp. (Described in POWER, Feb. 6, 1912.)

In a paper on "Uniform Systems of Cost Keeping," C. B. Segner called attion to the fact that it was not unusual for the price of one engine to be three times as large as that of another make of the same size. He attributed this great discrepancy largely to different methods used in estimating the cost of production, many concerns failing through marketing their product below the total cost. So strongly impressed was the association with the importance of this subject that it was determined to make a consideration of cost accounting a special feature of the next convention.

In a paper on "Practical Results from Gas Power," Charles Kratsch compared the cost of power as developed by electricity, steam, gasoline and illuminating gas and showed that there should be a large and profitable field for power production from illuminating gas in large cities.

In presenting a paper on "The Manufacturer and the College Man," Prof. George W. Munro, of Purdue University, called attention to the way the technical graduates are being absorbed by the large corporations and pointed out some of the problems presented to the smaller manufacturers in securing and utilizing the college man.

Following Professor Munro, Mr. McCulloch, of the National Implement & Vehicle Association, spoke on the benefits to be derived from permanent organization and hearty coöperation in a craft and instanced the success of concerted protest to the Interstate Commerce Commission against freight rate advances.

The program for the day was closed with an address by F. L. Walsh, of the Independent Petroleum Marketers' Association, on the desirability of establishing recognized standards in gas-engine oil, which he thought should be sold on specification rather than by trade name.

In the absence of A. E. Potter, his paper on "Gas Engine Economy" was read by R. A. Oglesby. The paper was largely devoted to an analysis of the results of carbureter tests published by Professor Munro in the March *Journal* of the American Society of Mechanical Engineers, the final conclusion being that engine efficiency depends primarily on correct mixture (a matter emphasized by E. H. Stickels in the afternoon) and to a lesser degree on a correct ignition system and the selection of lubricants.

"Application of Producer Gas to Brass Melting," a paper by B. M. Herr, described the application of producer gas to several heating processes and gave in detail the results of tests on producer gas and other fuels in brass foundry work.

One of the very interesting papers of the convention was on "Gas Engine Paints," by G. W. C. Sedgewick, who explained the difficulties of securing acceptable finishing material; a filler that would not crack or peel off under the repeated expansion and contraction, due to the high temperatures; a loader to properly take the enamel and finally an enamel which would withstand the action of heat, water and oil.

During the convention the association decided to employ a salaried secretary who should devote his entire time to the interests of the association and elected H. R. Brate, of Lakemont, N. Y., to this important position. To provide for the increased expense the annual dues were raised from $5 to $10 per year and it is expected that under the new arrangement the membership will soon reach five hundred. The officers elected for the ensuing year are, president, O. C. Parker, LaCrosse, Wis.; vice-president, R. A. Oglesby, Indianapolis, Ind.; treasurer, O. M. Knoblock, South Bend., Ind.; executive committee, O. C. Parker, B. M. Walker and R. A. Oglesby.

After selecting Springfield, O., for the next meeting, the association adjourned.

Cheap Electricity in London

Electric power at one-eighth of a penny per unit may have seemed to the audience of Prof. Fleming at his opening University College lecture a figure not likely soon to be attained in this country. Yet, for all that is boasted of the future of "water-power countries." it is difficult to suppose that the lowest records of price in Great Britain will be easily surpassed anywhere.

Recent negotiations on three sites in the north of England have related to contracts for 1500 kw. at 0.15d. ($0.003), 4000 kw. at 0.123d. ($0.00246), and 10,000 kw. at 0.11d. ($0.0022) per unit. The last named is for an equalizing load—that is to say, the supplies have the option of switching off when their plant is occupied in the "peak" hours. The other two examples represent electro-metallurgical works taking a continuous supply for 24 hours a day.

Waste heat plays, of course, an important part in the settlement of such rates, and it must not be assumed that the day is fast approaching for the universal distribution of power at such prices for ordinary purposes from ordinary sources.—*London Times.*

Tests of Wood, Paper and Steel Pulleys

Inadvertently the accompanying table was omitted from the article on the above subject, which appeared on page 848 of the last issue.

This table gives the data and results of the tests described in the article as made by E. D. Biggs and the author, H. A. Woodworth, at Purdue University, in 1909, to determine the breaking strength of pulleys of various kinds wtth a view to disclosing their principal points of weakness.

C. L. Huston Lectures on Boiler Steel

Charles L. Huston, vice-president of the Lukens Iron & Steel Co., gave an instructive talk on the manufacture of boiler steel before the American Institute of Boiler Inspectors at the latter's quarters, 29 West Thirty-ninth St., New York City, Friday evening, Nov. 29. The lecture was well illustrated by lantern slides.

After his talk on the processes of boiler steel manufacture, Mr. Huston showed several slides illustrating sections of ingots. The ingots were selected at random and planed down and analysis made so as to show the segregation of the carbon, sulphur, phosphorus and manganese.

It was interesting to note the distribution of holes at the edges of the ingots. These holes are caused by the action of the gases during the cooling of the ingot. Of the ingots illustrated none showed piping at the center. The speaker explained that when the ingot was rolled into plate form the honeycombed edges were cut off to insure a perfect plate.

Sometimes the holes are present in the center of the plate and are not thoroughly rolled out after the heated ingot has passed through the rolls. Should this condition be very pronounced, the speaker said, the plate would show pitting after coming from the rolls, i.e., the surface of the plate would contain pits similar to those caused by sulphurous or acid boiler waters. The speaker said that these pits caused in the manufacture of the plate might accelerate the pitting action of bad boiler waters.

Mr. Huston said he did not recommend boiler-pressure tests based on a high tensile strength, and further claimed that he regarded a boiler made of 54,000-lb. tensile strength material to be safer in practice than one of 60,000- to 64,000-lb. tensile strength. Good boiler plate he considers is that which shows a tensile strength of somewhere between 50,000 and 60,000 lb.

To get the plate to show a high tensile strength, it is necessary to make it hard, and striving after very high tensile strength usually results in a hardness of the plate that borders on brittleness, and such plate is obviously poor as boiler material.

Asked as to the advantage of firebox steel over flange steel for boiler shells as recommended by the Massachusetts Board of Boiler Rules, the speaker said that firebox steel was from selected stock whereas flange steel was from standard stock. Mr. Huston thought that the use of firebox steel for boiler shells was very good as firebox steel is not supposed to blister and should it blister, the manufacturer must make good by furnishing a new plate. It was conceded that a boiler made of firebox steel was well worth the extra cost of the better quality steel.

William Kent related some very interesting experiences of the early days of boiler-plate manufacture.

PERSONAL

H. E. Risher is in charge of the newly established Chicago offices in the First National Bank Building, of the Evens & Howard Firebrick Co., of St. Louis.

Elmer E. Carr has accepted a position with the Evens & Howard Fire Brick Co., St. Louis, Mo., which company will exploit the Carr patent ventilated furnace arch.

L. H. Mesker has resigned as manager of the St. Louis branch of Manning, Maxwell & Moore, Inc., to be connected with the Ferro Machine & Foundry Co., Cleveland, Ohio, after Jan. 1, in its sales department.

DATA AND RESULTS OF TESTS ON TWENTY-FOUR INCH PULLEYS

1	2	3					4		5	6		7	8	9
		Rim					Arms			Bursting speed				
No. of Test	Kind of Material in pulleys	Style	Dia. in inches	Bdth. inches	Depth inches	Area sq.in.	No.	Area sq.in.	Weight in pounds	Rev. per min.	Periph-eral speed = V ft.per sec	Centrifu-gal ten-sion V^2 / const.	Character of fracture	Remarks
1	Wood.....	Solid	24	6.25	1.62	10.15	2	14.4	29.37	2720	284.7	810.54	Completely broken	
2	Wood.....	Solid	24	6.25	1.62	10.15	2	14.4	29.37	2550	266.9	712.35	Whole rim shattered	Arms remained.
3	Wood.....	Two sections	24	6.5	1.78	11.6	2	8.25	29.67	2210	231.8	534.99	Whole rim shattered	Arms remained.
4	Wood.....	Two sections	24	6.5	1.78	11.6	2	8.25	29.67	2110	220.8	487.53	Half of rim shattered	Arms and half of rim left on shaft.
5	Wood.....	Two sections	24	6.5	1.78	11.6	2	8.25	28.81	2390	251.0	630.01	Whole rim shattered	Arms remained on shaft.
6	Wood.....	Two sections	24	6.5	1.78	11.6	2	8.25	28.81	2430	254.3	646.68	Half of rim shattered	Arms and half of rim left on shaft.
7	Wood.....	Two sections	24	6.5	1.78	11.6	2	8.25	28.81	2360	247	610.09	Half of rim shattered	Arms and half of rim left on shaft.
8	Wood.....	Two sections	24	6.5	1.78	11.6	2	8.25	28.81	2420	253.3	641.61	Whole rim shattered	Arms remained, slightly shattered.
9	Wood.....	Two sections	24	6.5	1.78	11.6	2	8.25	28.81	2570	258.5	668.22	Whole rim shattered	Arms remained.
10	Wood.....	Two sections	24	6.5	1.78	11.6	2	8.25	28.81	2535	244.4	597.31	Half of rim shattered	Arms and half of rim left on shaft.
11	Cast iron..	Solid	24	6.0	0.406	2.44	6	0.99	70.44	3720	389.4	15,163.2	Not fractured	Not sufficient power.
12	Cast iron..	Solid	24	6.0	0.406	2.44	6	0.99	70.44	3380	353.8	12,517.4	Not fractured	Not sufficient power.
13	Paper.....	Solid	24	6.0	1.75	10.5	Solid web 1.5 thick		77.37	2820	295.2	871.43	Portion of rim thrown off	Rim fastened to web by wooden pins.
14	Paper.....	Solid	24	6.0	1.75	10.5	Solid web 1.5 thick		77.37	2930	306.7	940.65	Portion of rim thrown off	Rim fastened to web by wooden pins.
15	Steel.....	Two sections	24	6.75	0.0625	0.422	6	0.656	41.75	2240	234.5	5,499.0	Flanges and bolts bent	Flanges riveted on to rim.
16	Steel.....	Two sections	24	6.75	0.0625	0.422	6	0.656	41.75	2240	234.5	5,499.0	Flanges torn off	Some rivets sheared.